APPLICATION OF CPM/PERT IN PROJECT MANAGEMENT

IN BURMESE INDUSTRIES

by

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CONTENTS

CHAPTER 1

Introduction.

The complexity of modern industrial and governmental enterprises with the consequent increase in the quantity and complexity of managerial decisions have made obsolete the traditional managerial methods of planning and cost control.[1] Thus management is turning increasingly to the newer scientific methods of solving problems.

1.1 Systems Concept and Modern Management.

Modern organizations are linked together in complex ways. This means that not only are individual organizations large and complex, but the systems formed by the interlinked organizations which in turn form our society are even more so. The complexity and difficulty of managerial problems increase sharply with time. The urgency to solve problems increases considerably, while the risk of failure in problem solving becomes even more apparent.

There is a greater degree of uncertainty involved in the economy, so that the delineation of the best alternative in any of the decision problems faced

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1. David I. Cleland, Systems Analysis and Project Management. (New York, McGraw-Hill Inc., 1968). p.7.

the manager is difficult than ever.[1]

The management philosophy of the manager must change with the patterns in management, for only a philosophy which is developed on such a base is adequate for today's complex management tasks.[2] One major idea lies at the root of the modern scientific approach to management. The idea, the systems concept, has had a substantial impact on both planning and execution functions of management.

The systems concept or view point is the simple recognition that any organization is a system, made up of segments, each of which has its own goals.[3] These segments are interrelated and interacting forming a unified whole. Thus, a system is composed of a hierarchy

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1. Stanley Young, Management : A Systems Analysis. (Glenview, Illinois, Scott Foreman and Co., 1966). p.15
2. Richard A. Johnson, "Systems Theory and Management," Management Science, (Jan., 1964). p.88.
3. Peter P. Schoderbek, Management Systems. (New York, John Wiley & Sons, Inc., 1967). p.79.
   See also,
   Edgar F. Huse and James L. Bowditch, Behavior in Organizations : A Systems Approach. (Phillippines, Addison-Wesley Publishing Co., Inc., 1973).
   William A. Shrode, Organization and Management : Basic Systems Concepts. (Homewood, Ill., R.D. Irwin, 1974).
   D. Katz and R.L. Kahn. Common Characteristics of Open Systems, Systems Thinking, ed. by F.E. Emery. (Harmondsworth, Middlesex, Penguin Books Inc., 1969).
   Stanford L. Optner, Systems Analysis for Business Management. (Englewood Cliffs, Prentice-Hall, 1960).

of subsystems. That is, the parts that form the major system may themselves be systems and their parts may be systems and so on. For example, the world economy can be considered to be a system, in which the various national economies are subsystems. In turn, each national economy is composed of its various industries; each industry is composed of firms and so on.

The manager realizes that he can achieve the overall goals of the organization, only by viewing the entire system and seeking to understand and measure the interrelationships, and to integrate them in a fashion which enables the organization to effectively pursue its goals.[1]

This means that, some functional unit within an organization may not achieve its objectives, for what is best for the whole may not necessarily be for each component of the system. Thus, when a wide variety of products are produced in relatively small quantities, the performance of the production department may be falling off, yet if this leads to greater total revenue, because no sales are lost, the overall impact may be positive. This simple realization is the essence of systems viewpoint, which has led to more effective management decisions, and to organizing for the efficient execution of decisions.

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1. William R. King, The Systems Concept in Management, The Journal of Industrial Engineering. (May, 1967), p. 322.

(a) Project Management.

The systems concept has caused revolutionary changes in management. The example of this is the emergence of project management organization. It is based on the realization that modern organizations are so complex as to preclude effective management using traditional organizational structures and relationships. Traditional philosophy is based on a vertical flow of authority and responsibility relationships,and emphasis only parts and segments of the organization.[1] It does not place sufficient importance on the interrelationships and integration of activities involved in the total array.

As projects become large and complex, top management cannot be expected to comprehend all the details and intricacies involved in the management of each activity. Thus the need for unifying agent in these projects motivates the development of a project type organization, superimposed on the traditional and functional organizational structure.[2]

The project organization becomes the structural and authority framework, through which all the project efforts are coordinated and integrated into the common objective. The project organization is not an independent

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1. David I. Cleland, op.cit., p.13.
2. Paul C. Goddis. The Project Manager, Harvard Business Review. (May-June, 1969). p.15.

entity, it is part of a larger system.

The project manager or the unifying agent may be defined as that individual, who is appointed to accomplish the task of integrating functional and extra-organizational efforts, directed toward the development and acquisition of a specific project.[1]

Project management provides the concentrated management attention that a complex and unfamiliar undertaking is likely to demand. Project management becomes a logical approach to the project, speeds decision making and cuts managements' job to a reasonable level.[2]

(b) Emergence of CPM/PERT [3]

The modern organization, be it governmental, educational or industrial, is confronted with a continuing stream of potential projects. The tempo and complexity of modern age projects require immediate answers when problems occur.

No other aspect of project management is so essential to success as planning, scheduling and control. The only planning techniques available were those which had been developed for use in factories. These techniques suffered from serious limitations as far as project work

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1. David I. Cleland and William R. King, Management : A Systems Approach. (New York, McGraw-Hill Inc., 1972). p.143.
2. W.A. Meinhart and Leon M. Delionback. Project Management, Academy of Managemant Journal. (December, 1964). p. 20.
3. Critical Path Method/Program Evaluation and Review Technique; see Chap. III, 3.2, p.34.

was concerned. Thus, analytical techniques have been developed for the smooth functioning of modern complex industrial society. This new approach to the problem is called management science. It provides the tools necessary for management to perform effectively. Management science has developed network analysis techniques to meet the needs of project management.

CPM and PERT are the acronyms for the best known of these network based techniques. These techniques are now the accepted methods of planning and control in many organizations and are becoming widely known and extensively used in many project type industries and operations.[1] These techniques have become part of everyday language of industry. The amount of literature on the technique has increased at an exponential rate. With CPM/PERT, the same data can be used with any other procedure, (e.g. Bar Chart, Gantt chart) but the results we may expect from these new techniques are considerably improved and more useful.[2]

If we are to control a project, we must develop a working model or a master plan, that will complete the entire project in the least time, least cost and with

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1. R.L. Martino, Applied Operational Planning. (New York, American Management Association, 1964). p.14.
2. Ibid., p.53.

smallest degree of risk. The master plan must be dynamic. It must give us the ability to fulfill the following requirements.[1]

1. Revising and updating it immediately.
2. Considering the costs of several alternatives.
3. Understanding and evaluating the effect of changes without delay.
4. Establishing criteria for resource allocation and scheduling.
5. Providing criteria for evaluating the accuracy of estimates.
6. Taking notice of deviations between prediction and actual result, so the level of management effected may take the necessary action.

CPM/PERT meets and surpasses all these requirements. From its inception in 1958, CPM/PERT has not only aroused widespread interest in the business community, but has also won acceptance by a growing segment of industry, as an improved management and control technique.[2]

The range of application of these techniques has spread like ripples on a pool, embracing building, civil engineering, and plant maintenance from launching a

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1. John Stanley Baumgartner, Project Management. (Homewood, Ill., Richard D. Irwin, Inc., 1963). p.14.
2. Peter P. Schoderbek, op.cit., p.404.

satellite to launching a new ice cream, from organizing a major management reshuffle to organizing a stage production, from planning a heart operation to planning a new clerical system, from power station to pencil production.[1] In short, the versatility of CPM/PERT concept is likely to be benefit in any projects with a definable beginning and a definable ending, (i.e. static type of project) and which need coordinating. Such projects have the common characteristic of being special purpose or one-time through.

1.2 Purpose and Scope of the Study.

These techniques offer an integrated management control system which is particularly suited to complex projects and situations with planning uncertainty. However, the use of these techniques seem to be confined to industrially developed countries only.

There seem to have no systematic planning techniques applied to industries and projects in Burma. It is even difficult to point out that the traditional planning techniques are applied systematically.

The general feeling is that, these techniques are not applicable in Burma, as many view the situation

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1. William D. Brinckol, Managerial Operations Research. (New York, McGraw-Hill Co., 1969). p.125.

too early for application. But, it would be worthwhile to try out in a real situation and see if the complex projects could be managed through the use of these techniques, and find out what are the conditions or factors that actually pose as obstacles. If these obstacles could be removed or controlled, these techniques would virtually be contributory in the economic and industrial development of Burma. To justify this line of thinking, a search into the feasibility of the use of these techniques would be appropriate.

This study is based on a library research of current readings in Network Analysis techniques, and a field research conducted at the Sinmalike Dockyard Corporation and the Construction Corporation.

The Pyithu Hluttaw building project of the Construction Corporation, the 500-ton oil barge construction project and lathe machine assembly project of the Sinmalike Dockyard Corporation are the three concrete case studies undertaken in this research.

The oil barge construction project and the lathe assembly project of the sinmalike Dockyard Corporation are tried out with CPM/PERT to find out whether these techniques are applicable in the Burmese industrial environment. In Pyithu Hluttaw Building Project of the Construction Corporation, as it is not yet possible for the trial application of CPM/PERT, only the study of the project organization or the set up of the project team is made. However, this study potrays the existing conditions for project implementation, and indicates to a certain extent, the ways of implementing projects in Burmese industries. Although, time analysis, resource analysis and cost analysis can be made with the CPM/PERT technique, only time analysis is carried out in the case studies of the sinmalike Dockyard Corporation.

Emergence of CPM/PERT and its application in project managementhave been introduced in this chapter. Significance of projects in planning developing countries is explained briefly in chapter 2. In chapter 3, theoretical considerations on the methods of CPM/PERT are treated in some detail. The existing envirooment for the implementation of projects in Burma and the research procedure of CPM/PERT application followed in this study, are presented in chapter 4. Following this, in chapter 5, the case studies undertaken at the two Corporations are discussed in detail. The benefits achieved from the above experiments, the limitations in using these techniques, and the recommendations for the successful application of these techniques are put forward in the concluding chapter.

CHAPTER 2

Significance of Projects in Planning Developing Economies

In developing countries, planning has been adopted as the main instrument of speeding up their national development. Planning is essential in realizing national development and it makes a development effort effective. Planning is followed by the formulation of individual project plans. Each project is evaluated on the basis of its social and economic values to determine the scale of development. Thus the degree of success in executing the plans is determined in a large measure by the preparation and implementation of projects.

2.1 Situation of Developing Countries.

Developing countries can be divided into three categories.

The first category is made up of a large body of poor states that would need time and technology to build modern developed economies. The nations in this category include countries like Malaysia, Taiwan, Singapore, South Korea, Mexico and Brazil.

The second contains nations that have some raw materials, modern economic infrastructure, trained technicians and engineers, and thus could achieve self-sustaining economic growth. They need significant financial help and special treatment by industrial aid to spur export of their goods and imports of technology. This group includes Peru, Liberia, Jordan, Egypt and Thailand.

The third category comprises countries which are the globe's true basket cases. They have few easily exploitable resources to sell abroad and most of these countries are unable to grow enough food to feed themselves. The most notable countries in this category are Ethiopia, Somalia, and Bangladash.

The three worlds comprise approximately 1725 million inhabitants.[1]

Agriculture forms not only the biggest sector in the economy of the developing countries of South East Asia, in terms of both manpower and output, but also the base on which the industrial and other economic superstructure must be built. Over 60% of the people in these countries live on agriculture, and nearly one half of the national product is of agriculture origin. In all these countries, agriculture is clearly the most basic industry for domestic consumption. It also supplies raw materials for domestic industry, and makes the maximum contribution towards an increase in export earnings.

If these things cannot be done at a time when countries are attempting to accelerate economic

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1. As estimated in Time, Dec.22, 1975.

development, there would be serious consequences, such as a sharp rise in the cost of living, a strained or increased pressure on the balance of payments, a slowing down of the rate of industrial development or a combination of both.[1]

The share of manufacturing industry in the gross national product in the developing countries of South East Asia ranges from 5% (Ceylon) to 25% (China)[2]. In many developing countries, basic necessities such as living wages, decent dwellings, and schools for children are out of reach.

2.2 Development Plans in South East Asia.

Virtually every developing country has its development plans for meeting the demands of increasing population and for improving the economic and social conditions mentioned above.

Planning involves meeting rational choices among feasible courses of investment and development possibilities, on the basis of social and economic considerations.[3]

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1. Economic Development and Planning in Asia and the Far East, Agriculture Sector, United Nations, New York, 1967. p.2.
2. Development Programming Techniques Series No.2, Formulating Industrial Development Programmers with special reference to Asia and the Far East, U.N., New York 1961. p.1.
3. Water Resources Project Planning, Water Resources Series No.41, United Nations, New York, 1972. p.11.

Wise exploitation of natural resources calls for careful and articulate planning. Valuable or uncoverable riches have been squandered due to lack of planning or poor planning. Haphazard and thoughtless exploitation of resources can be avoided through careful planning.

Planning for social and economic development aims at the best utilization of human and natural resources to meet popular demand for improved levels of living[1].

Agricultural development and industrial development plans have been adopted especially in developing countries of South East Asia. In these countries, agricultural development aims at the economic and social advancement of the population and productivity. Agriculture is also conditioned by the development of other branches of the economy, particularly of manufacturing industries.

The plans for industrial development in these countries are made to increase the stability of the economy, to achieve a rapid growth in national income and to create skills and experiences, that will in the future lead to more rapid increase in productivity and a more flexible economy.[2]

The objectives of industrial planning in countries of South East Asia seem to have been derived

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1. Development Programming Techniques Series No.2, Ibid., p.106.
2. Ibid.,p.12.

from the overall objectives set forth in their economic development plans. Improvement in the level of living, expansion of employment opportunities, and attainment of a balance in international payments are the three objectives most commonly found in the plans of South East Asian countries.[1]

2.3 Evolvement of Industrial Projects within National Economic Plans.

In implementing development plans, projects for different sectors of the economy are selected and carried out to fulfil the objectives of the plans.

In theory, the identification, selection and preparation of projects should follow from an overall national development plan which will have identified the priority sectors and production targets, thereby providing the criteria for the selection of projects.

Although, projects are sometimes derived from plans in this way, in practice they are usually selected to meet identified specific needs, or to take advantage of special opportunities - the presence of natural resources or some other special circumstances permitting production of a commodity at a relatively low cost, or the existence of domestic demand, either satisfied

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1. Detailed discussions of the aims of industrial development plans are given in Ibid., Chap.I.

through imports, with cost sufficiently high to permit domestic production.[1]

A sound development plan requires a great deal of knowledge about potential projects. A point has been made that good realistic plans can hardly be formulated in the absence of a great deal of project planning and proper economic appraisal of projects.[2]

Cost benefit analysis is a method adopted for the rational selection of investment projects from the financial point of view. The appraisal of a project from the financial point of view is concerned with projects that produce revenue. Of course many projects do not fall into this category - eg. highway projects and educational projects; and the financial appraisal of such projects differ from that of revenue producing ones. Although this paper does not primarily concern with the project appraisal and selection techniques, it will be explained briefly.

In appraising the project from an economic point of view, the following factors are considered.[3]

1. Whether the development of the project in a sector of the economy is likely to contribute

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1. John A. King Jr., Economic Development Projects and Their Appraisal. (Baltimore, Maryland, The Johns Hopkins Press, 1967).p.4.
2. Ian M.D. Little and James A. Mirleas, Manual of Industrial Project Analysis in Developing Countries, Vol. II. (OECD ,1969). p.56.
3. These factors are adapted from John A. King Jr.,op.cit., p.5.

significantly towards the development of whole economy.

2. Whether the project is likely to contribute effectively towards the development of other sectors.
3. Whether that contribution is likely to be large enough to justify the use of the quantity of scarce resources that will be needed - invested capital domestic and foreign, management talent, skilled labour and the like.

All project proposals define and precisely state the objectives. Any project regardless of its size, field and technological basis is an integral part of long range national development plans. Every project contribute directly or indirectly to the economy. eg. Pesticides plant project can control epidemic diseases and pects,and promote agricultural yields. Increase in crop yields will certainly increase both the national income and foreign exchange earnings. More agricultural yields mean more agricultural raw materials for the existing and future agrobased industries. Hence agricultural and industrial sectors are naturally promoted. Dam projects can provide power generation, irrigation and transportation facility which contributues to regional development.

The evolvement of projects in economic plans is in such a way that the projects which are formulated must be in line with the short and long term plans to achieve balanced growth. Success or failure of plans depend upon the projects meeting of due dates. Hence plans require projects.

2.4 Development Plans of Burma.

Like other developing countries of Asia, Burma depends upon agriculture. Generally, production in Burma is characterized by age-old techniques and capital equipmant is relatively limited.

The economy of Burma had been greatly disrupted by world war II, that in 1946, approximately half of Burma's national capital was destroyed.[1] Thus in 1952, Pyidawtha Conference was held by the Government to discuss and pass ten large-scale plans for the welfare of the people and for the creation of a new state. These plans comprised of agricultural and rural development five-year plan, housing plan, transport and communication plan and education plan among other things. Agriculture and rural development five-year plan included commodity projects (rice, groundnut, cotton etc.) and subsidiary projects (Irrigation, agricultural, fertilizer, etc.).

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1. The Pyidawtha Conference, Aug. 4-17, Resolution and Speeches, 1952. p.35.

This program was made with the view to make Burma self-sufficient in commodities and to increase agriculture production.[1]

During 1956-57, some 1680 commercial projects were completed with the help of Pyidawtha grants in 192 districts.[2] The Industrial Development Corporation, which was founded in 1952, under the Industrial Development Act of 1952, completed many projects during the eight years time, including Namti Sugar factory, Pyinmana sugar factory, Okkyin jute mill, Ywama Insein Steel mill, Thayetmyo Cement factory extension project, and Thamaing Cotton Spinning and Weaving factory.[3]

Also in 1954, an economic and social development plan for six years was adopted. This plan included many projects to be implemented in major sectors such as, agriculture, transportation, power, industry, and the like, with an aim to create an economy, capable of dynamic growth for the indefinite future.

The first development plan of the Revolutionary Council was launched in 1966-67 for four years. This plan was to increase the value of gross output by 5% a

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1. Ibid., p.23.
2. Burma, The Thirteenth Anniversary, Vol.X, No.1, Jan., 1951, p.63.
3. Burma, The Tenth Anniversary, Vol. VIII, No.2, Jan., 1958, p.19.

year, per capita consumption by 4% and investment at an average rate of over 15% per annum.[1] Priority was given to modernization and diversification of agriculture, although emphasis was placed on the expansion of industries particularly with use of domestic raw materials.[2]

The first four-year plan of the twenty-year long terms plan was launched from 1971-72 to 1974-75, with the objective to improve economic conditions and overcome economic illness at present and in the future.[3] Some major projects which have been completed during 1966 to 1975 include the Kyunchaung fertilizer plant, the Paleik textile mill, the Sittang Paper Mill, the Pokokku Cigarette factory, the Kyetmauttaung irrigation project, the Salai fertilizer plant, etc.

2.5 Experiences of Developing Countries in Project Management.

Information on the techniques used to implement projects in developing countries are not readily available. In most developing countries there seem to have

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1. The Far East and Australasia, A survey and Dictionary of Asia and the Pacific. London, Europa Publications Limited, 1970. p.398.
2. Ibid, p.399.
3. Summarised Report of the seminar on the short term and long Term Economic Plans of the Union of Burma, 1973, (in Burmese), p.11.

no systematic method applied in project management Traditional planning techniques such as bar chart, Gantt chart, and flow charts seem to be in use often, but not as a true tool of management. The literature on network planning techniques have been introduced theoretically and informally within industry, but never been used practically.[1]

Developing countries encounter similar problems and shortcomings in the course of industrial development projects in general and introducing and applying network analysis techniques in project management in particular.

Network analysis techniques have so far a rather limited application in developing countries.[2] As a very useful project management tool one would think that it is widely accepted and applied. But there are a number of factors which discredit these techniques and hinder their further application in developing countries. Main factors may be stated as follows.

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1. Burmese industrial managers by and large are acquainted with Planning and Control Techniques such as CPM/PERT, but still lack the practical experience in general.
2. H.J.M. Lombaers, edited, Project Planning by Network Analysis. (Amsterdam, London, North Holland Publishing Co., 1969). p.55.

(a) Lack of Well Prepared Feasibility Study of Projects.

Rapid rates of industrial growth are frequently not backed by well studied and prepared projects to achieve the targets for which network techniques are to be used to programme, coordinate and control their implementation.[1] Even with well conceived projects and well prepared feasibility studies, time may have elapsed for some reason or another, such as in seeking financiers, between the completion of a study and the commencement of the execution of the project, during which many relevant circumstances are likely to have changed. Since the work required in implementing the project should be based primarily on the feasibility study, in many developing countries, project implementation is based on unrealistic technical parameters and estimates and hence entail interruption of work, alterations and increase in costs.[2]

(b) Reluctance of Top Management to Apply New Techniques.

The results of a recent survey indicate that one of the significant problems associated with the network technique is due not to the inadequacy of the technique itself, but rather the failure of management to gain

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1. Water Resource Project Planning, op.cit.,p.210.
2. H.J.M. Lombaers, op.cit., p.55.

its acceptance.[1]

Due to lack of reliable information, which would have identified the existing problems, or to the fact that top management is not acquainted with these techniques and with their capabilities in saving time, resources, and costs that will result in applying them, top management might claim that current programming and control practices so far used in project management are satisfactory.[2]

Furthermore, project management may develop an aggregate project implementation network after it puts the project into execution, with no further detailed programming. This may be due to two reasons. The first is that project management might be under pressure from the industrial development agency or some higher executives to start the project immediately for some political reasons. The second is that owing to top management having inadequate knowledge of these techniques, they may have no appreciation and enthusiasms for these techniques.

(c) Lack of Qualified Personnel.

Because of the shortage of well qualified personnel who can develop the correct logic of the

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1. Ibid., p.56
2. Peter P. Schoderbek, Management Systems. (New York, London, Sydney, John Wiley & Sons, Inc., 1967).p.404.

strategy of the project and provide reliable estimates for activity parameters, foreign consultants are being called upon to assist in preparing and programming project implementation.[1] As many of them are not well acquainted with the local conditions, the schedules they develop are for the most part based on unrealisble estimates of time durations.

Those who have not been used to these techniques before may fear that the top management may adopt tight control by using detailed programming achieved by them.[2] Thus they may be unwilling to provide higher management with a detail plan or even carry out any detail planning.

(d) Inadequate Project Organization.

One of the major problems which deters the effective application of network analysis techniques in project planning and control is the lack of adequate organization, well staffed and equipped not only to programme but also to coordinate and monitor implementation process.[3] Mal-organization, improper assignment of the responsibilities, duplication of functions, lack of coordination between the parties participating in implement-

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1. Water Resource Project Planning, op.cit., p.212.
2. Peter. P. Schoderhek, op.cit, p.407.
3. H.J.M. Lombaers, op.cit., p.56.

ing the project, inadequate progress reporting and follow-up are evidentin most cases.

The information collected is for the most part sketchy and most of the progress reports are qualitative rather than quantitative, which can be interpreted in different ways and which are of little value to project monitoring.[1]

Since conditions change in the course of implementation, a project implementation schedule that was originally well prepared may cease to be so soon after its execution has started, if there is no reliable information available for updating. Work is then performed according to schedule which has ceased to be valid or as if it had not been programmed before, and hence problems are only recognized when they occur.

(e) Inadequate Financial Assistance.

Within any country's development program, various kinds of project compete for funds from the budget. If required investment outlay exceeds available resources, the projects are subjected to a critical examination and the total is reduced by use of priority considerations.[2]

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1. Ibid. p.57.
2. Government Budgeting and Economic Planning in Developing Countries, U.N., New York, 1966. p.42.

In many developing countries, there are long delays in obtaining financial approval for development program. Foreign exchange is also required to finance imports needed for the projects and includes such items as raw materials, machinery, and spare parts. Sufficient fund is needed for a project to be completed on schedule. In most developing countries, sufficient budget might not be alloted for the projects on time, which the network planning techniques have been applied to control their implementation, thus causing disturbances of work, and the progress of the projects will be out of schedule or plan.

2.6 The Need for Sound methods of Project Management.

A project is a plan which is deemed necessary in the development of a country's economy and utilizing the resources of a country to the fullest possible extent. A project is a scheme to be implemented and has definite starting and end points. It is a one-time effort. As such, a project has to be implemented and completed within a definite period of time, in relation to overall development plan of the country. Thus effective management of project is a prerequisite. Effective project management requires sound project planning and control techniques to overcome the problems and shortcomings, in the course of implementing development projects,

On the other hand, no matter how well-conceived and formulated, there is no project that can yield satisfactory results if there is a serious failure in implementation.

The planning and carrying out of a project is a challenging task. Concurrently, modern business and modern technology are so complex that more and more planning and more and more time are both needed before a project can come to its successful end.[1] In order to accomplish the project tasks efficiently, project management must plan and schedule largely on the basis of experience with similar projects.

No proper plan however, works out smoothly in practice, even if it is perfect theoretically. Unforeseen delays, unpredictable constraints and other unknown factors can effect the smooth operation. This warrants for an effective project management system, which on the basis of actual progress of work, reviews the current procedures and forecasts the future requirements of the job, so that the work may be successfully completed.[2]

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1. Ibid., p.3.
2. Report of the seminar- cum-study tour on load despatch techniques and application of computer technology to power system engineering problems, United Nations, New York, 1970. p.182.

The need for sound methods of project management in developing countries is also mentioned in the report of the Interregional Symposium on Industrial Project Evaluation as follows :

" Integrated implementation of development programs presented a difficult problem for the developing countries and this had not been given attention".

" The follow-up of approved projects in developing countries have been impeded by difficulties in the implementation of projects, in the form of delays in the planned time-schedule and overruns in costs. One of the most effective means of overcoming these difficulties, and reducing cost and time in the implementation of projects lies in the use of network analysis techniques, including Critical Path Method in planning and implementing projects."

" The concept of providing every industrial program with a tentative implementation network plan be further explored. Such a plan would provide the vehicle for smooth follow -up and supervision after completion of the feasibility study and evaluation of the project."

" Further research in this field is needed preferably with the help of pilot studies of the actual use of such methods with a view to finding out its operational feasibility in developing countries."

As the successful implementation of sound projects is of great importance in the industrial development of developing countries, the need for sound methods of project management becomes paramount.

Two well known project management methods or techniques are explained briefly in the next chapter.

CHAPTER 3

Methods of Project Management.

Most of the troubles that confront project management on the way to completion of the project are traceable directly to faulty planning. Probably, more planning effort is devoted to developing schedules, than to any other planning tasks, since it is the task most obviously needed. Planning and control based upon schedules are the essentials of project management.[1] Two types of project management techniques are as follows.

3.1 Traditional Planning Techniques.

Three well known traditional planning techniques, which are the forerunners of network analysis techniques are, the Bar Chart, the Gantt Chart and the milestone methods.

Bar Chart method was developed in 1917. Bar charts are widely used and popular because they are easily read and thus an excellent form of communication.Bar Charts show duration in time. Each bar represents a succession of activities performed by one man, one team or one machine only. There are no cross-connections to show directly how the timing of one man

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1. John Stanley Baumgartner, op.cit., p.13.

or machine depends on the others, so the sequential relationship is not completely prescribed.[1]

As an example, the inadequacy of Bar Charts may be illustrated in Fig. (1).

A Bar Chart is quite adequate for planning a project which contains only eleven jobs, and the mistakes incorporated in the Figure, would not escape the eye of an experienced man. The mistakes in this figure are.[2]

(1) The chart shows an interval of two hours between dismantling the heat exchanger and renewing the tube bundle whereas the latter job could begin immediately after the former.

(2) The spreaders in the reaction column cannot be replaced, until the column has been completely dismantled and so the plan is calling for the replacement of spreaders two hours before it can possibly do so.

When one thinks of a project made up of hundreds or even thousands of jobs, one finds it to accept that lapses of this sort go unnoticed, that wrong deductions are made and that wrong priorities

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1. Albert Battersby, Network Analysis for Planning and Scheduling. 2nd.ed. (London, Beccles, William Cowes & Sons Ltd., 1967). p.7.
2. Ibid, p.8.

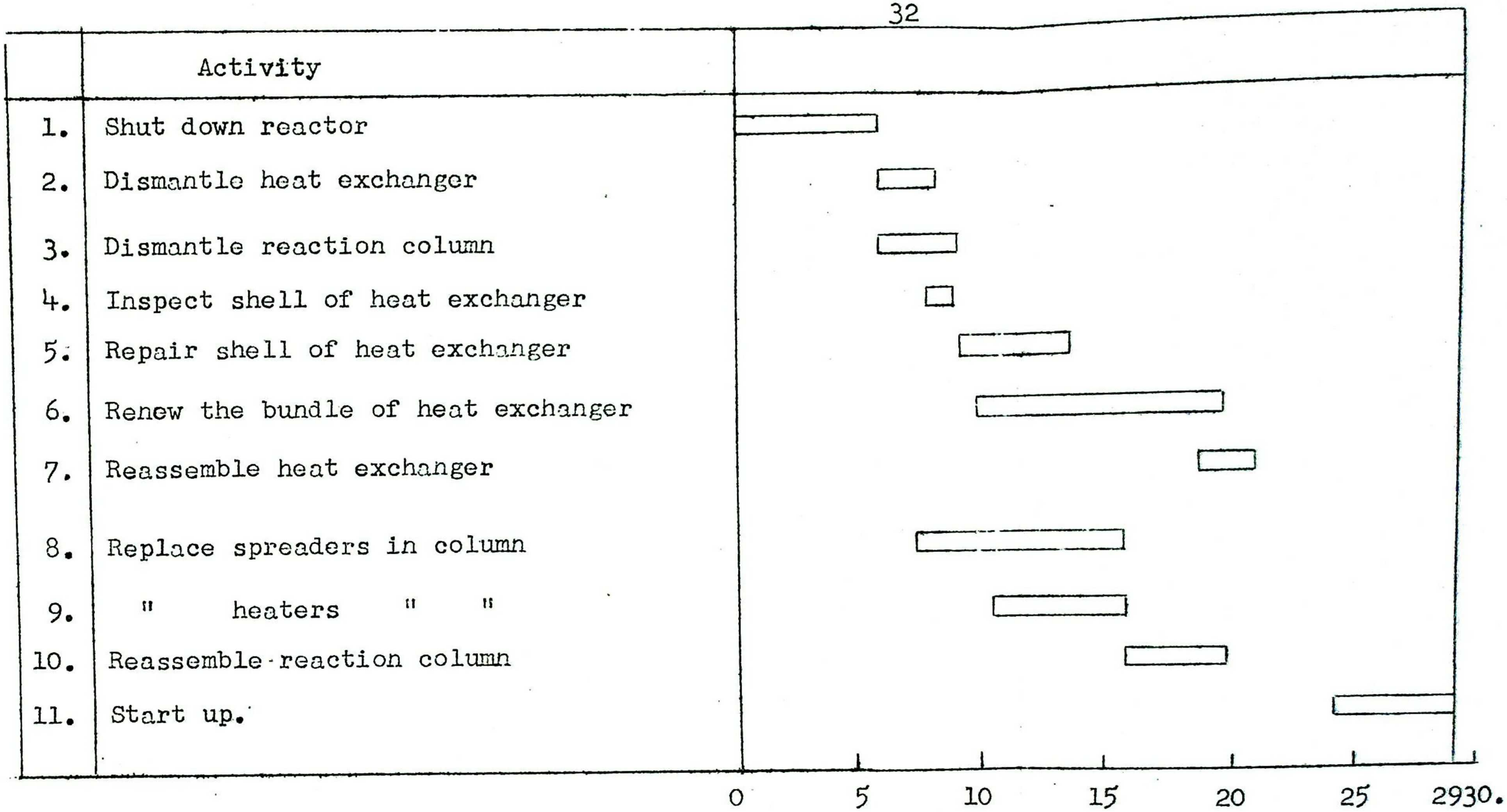

Fig. (1). A plan for a maintenance shut down on a chemical plant, which makes mephistophelene in a continuous reactor.

Source : Albert Battersly, Network Analysis for Planning and Scheduling. (London, Beccles, William Cowes & Sons. Ltd., 1967). p.7.

are assigned in consequence.[1]

The Gantt technique was developed by Henery L. Gantt in the late 1800s. The Gantt chart is basically a bar chart, showing planned and actual performance for those resources that management desires to control.[2] In addition, major factors that create variance (i.e. over production or under production) are coded and depicted on the chart. This method is usually applied to highly repetitive production operations.

The milestone method is the refinement of the Gantt chart. It was developed after world war II. In order to obtain a more detailed view of program status, individual milestones are called within each horizontal bar on the chart.[3] The milestone method is usually applied to development projects.

Traditional scheduling methods of which the afore mentioned methods are included, have limitations, when they are used to control one time projects.[4]

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1. James J. O'Brien, edited, Scheduling Handbook. (New York, Mcgraw-Hill Book Co., 1969). p.299.
2. P.J. Benman, Precedence Networks for Project Planning and Control. (England, McGraw-Hill Book Co., 1972). p.8
3. Ibid, p.9
4. David I. Cleland and William R. King, Systems, Organizations Analysis, Management : A Book of readings. (New York, McGraw-Hill Inc., 1969). p.338.

1. These techniques use time as the basis, against which the plan is drawn. They are therefore only applicable to where time estimates can be made with reasonable accuracy. This is generally only true of a production situation and not in a one-time project, where times are often educated guess.
2. Large projects composed of many interrelated activities and the Gantt chart or the milestone chart that attempts to detail these becomes unmanageable and unreadable.
3. No chart is capable of depicting all the dependencies of activities upon each other. It is not detail enough to permit early detection of slippages.
4. None of the methods described, is truly capable of distributing resources or of controlling costs.

In the light of these difficulties, project management requires a tool that will better allow it to program, schedule and control large projects, in all the aspects of time resources and costs.

3.2 Network Analysis Techniques.

Various industries in developed countries have for sometime been exploring and testing new management methods of planning and control, with a view to increasing their efficiency and shortening the time required to complete projects. From the myriad experiments has emerged a series of Management Science or Operations Research techniques based upon networks.

Network analysis is a useful tool that produce models for planning scheduling and controlling projects. In network analysis, a model is represented by an arrow diagram.

In network analysis planning and scheduling are completely separated.

The technique provides a means of reprecenting graphically the different operations tnat make up a project, showing the logical sequence of work and the dependency of each operation on the others and on the whole project.[1] This is the planning function.

The scheduling function is performed by assigning time estimates to the operations, so that a work programme can be produced giving starting and finishing dates for each of the operations and the whole project.[2]

Some representatives of the forms of network analysis techniques are[3]

1. PERT (Program evaluation and Review Technique).

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1. R.L. Martino, Critical Path Network. (Wayne, Pennsylvania, Management Development Institute, Inc., 1967) p.11.
2. Ibid., p.13.
3. Richard I. Levin and Charles A. Kirkpatric, Planning and Control with PERT/CPM. (New York, Mcgraw-Hill Inc., 1966). p.152

2. CPM (Critical Path Method).
3. LESS (Least Cost Estimating and Scheduling System).
4. RAMPS (Resource Allocation and Multi-project Scheduling).
5. SCANS (Scheduling and Control by Automated Network Systems).
6. PACT (Production Analysis Control Techniques).
7. TRACE (Task Reporting and Current Evaluation).
8. CPPS (Critical Path Planning and Scheduling).
9. TOES (The Trade-off Evaluation System).
10. MPACS (Management Planning and Control System).

However, the two main contenders for the generic title are CPM and PERT.

CPM was developed by James E.Kally and Morgan R.Walker for dupout de Nemours and Co. and was first applied on large scale in 1957.

PERT was developed by various military and civil teams for the U.S. Navy, particularly for progressing the Polaris Missile Programme in 1958.

This paper will deal with CPM and PERT, the best known of these network-based techniques. It is first necessary to describe what the methods really are and how they should be used.

3.3 Essentials of CPM and PERT.

Before analysing CPM and PERT in detail, it is necessary to understand the two basic essentials of these techniques :

(a) Basic concepts of CPM and PERT.

(b) Network or the arrow diagram.

(a) Basic Concepts of CPM and PERT.

Whichever method is used, (CPM or PERT) a working model of a project is developed, from which a realistic schedule can be prepared.[1] It is important to understand the basic concepts which are common to both CPM and PERT.

(i) Event.

An event is a milestone in project progress; it represents a specific accomplishment and takes place at a particular instant of time.[2] An event does not have any dimension in time or effort; synonymous are "node" and "connector". The normal symbol used to represent an event on the network is a circle but other shapes are also employed. For example,

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1. R.L. Martino, Critical Path Networks, op.cit.,p.3.
2. James J. O'Brien, op.cit., p.41.

Different symbols are sometimes used on the same network to indicate different areas of responsibility, and the size of the event symbol is sometimes varied to emphasize the relative importance of certain events.[1]

(ii) Activity.

An activity is an individual operation in the project and is represent by an arrow, the length and slope of which are not significant.[2] An activity represents what is to be done between the achievement of any two events, these events being known as preceding and succeeding events.[3] Activities make use of time and resources, this time being called the activity duration. Commonly used terms synonymous with "activity" are "task" and "job".

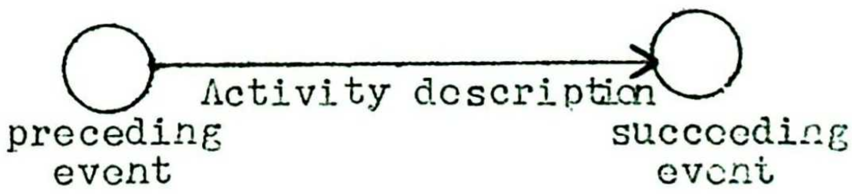

Fig. (2). Activity Symbol.

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1. H.S. Woodgate, Planning B Network. (London, Business Publications Limited, 1964). p.30.
2. K.G. Lockyer, An Introduction to Critical Path Analysis. (London, Sir Isaac Pitman & Sons Ltd., 1967), p.12.
3. F de R. Ha James J. O'Brien, op.cit., p.19.

(iii) Dummy Activity

Dummy activities are used to show the dependence of one event on another, where no resources are required and no time is taken between the events. It is also called a dependency arrow. Dummies are represented by dashed line arrows.

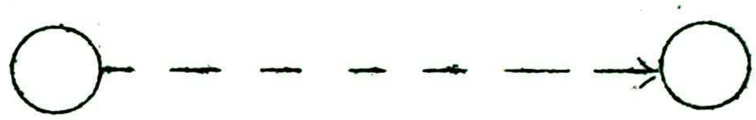

Fig. (3) Dummy activity.

(iv) Earliest Event Time.

This is the earliest date by which it is possible to start or finish the activity. It is obtained by summing the duration of the activity along each path of the network commencing at the first activity. Where two or more paths of activities lead into a common event, the largest of these summations is taken as the earliest event time.[1]

(v) Latest Event Time.

This is the latest date by which it is possible to start or finish the activity without delaying

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1. M.H. Chambers, M.H. Cullum, W.I. Morrison, Network Analysis and its application, Transactions of the Royal Institute of Naval Architects. (vol.107, 1965). p.505.

the finishing date of the project. Working back from the completion time of the final activity the latest event time for each activity is calculated by subtracting the activity duration from its latest event time.[1] When two or more paths lead to a common event, the smallest of these is taken as the latest event time.

(vi) Float or Slack.

Float time is to an activity, as slack time is to an event. Float is a measure of the maximum amount of time an activity can be delayed without affecting the completion date of the project.[2]

Slack is the amount of leeway available to an event and is derived from the difference between the earliest and latest dates for the event.

(vii) Critical Path.

Any paths from the start to the finish of a project which contains only jobs with no float is called critical path and directly affects the total project duration, i.e. it determines the length of the project.[3]

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1. H.S. Woodgate, op.cit., p.101.
   See also,
   James I. O'Brien, op.cit., pp. 38-42.
   Albert Batersly, op.cit., pp.28-29
2. H.S. Woodgate, op.cit., p.109.
3. J.A. Cannthers and Albert Battersly. Advances in Critical Path Methods, Operations Research Quarterly. (Dec., 1966). p.378.

Identification of the critical path is the main feature of CPM/PERT.

The activities along the critical path are called critical activities. If any activity along the critical path is delayed, the entire program will be correspondingly delayed. Management can devote resources to those activities along this path, in an effort to reduce the time requirement and thus shorten the overall program.[1]

(viii) Rules for Constructing a Network.[2]

There are a number of important rules connected with the handling of events and activities on a network. These rules must be followed in order to maintain the correct form of the network.

Rule 1. Each activity must have a predecessor and successor event. Similarly, each event must have a preceding and succeeding activity.

Rule 2. No given activity can be followed by an activity path which leads back to that same activity.

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1. Ibid., p.379.
2. These rules are adapted from -
   Robert W. Miller, Schedule Cost and Profit Control with PERT. (New York, McGraw-Hill, Inc., 1963). pp.33-38.
   Albert Battersly, op.cit., pp.10-15.
   H.S. Woodgate, op.cit., pp.29-39.
   R.L. Martino, Critical Path Networks, op.cit, pp.23-37.

This is called looping. see Fig. (4).

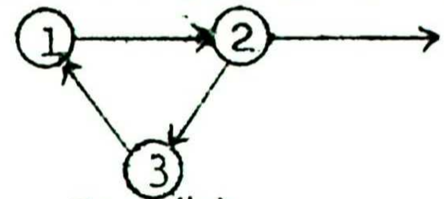


Fig. (4)

Rule 3. A dangle should not occur in a properly drawn network. A dangle is an event that has either no activity going into it or no activity going out it. In Figure (5) A and B are called danglers.

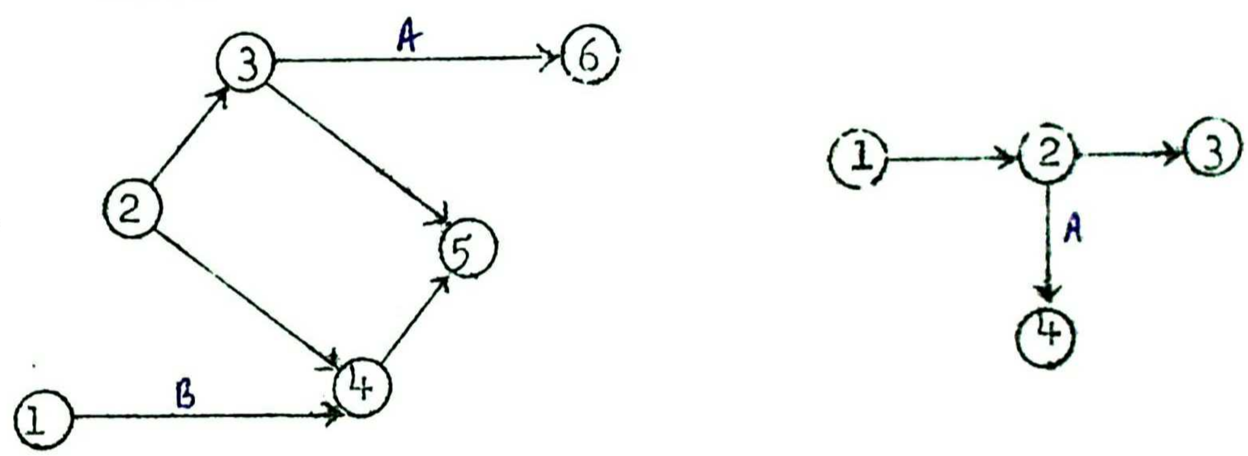


Fig. (5)

Rule 4. No single job may be shown more than once in an arrow diagram.

Rule 5. A complete arrow diagram should have only one point of entry and one exist. But in case of a considdrably complex project, there may be more than one point of entry or exist.

Rule 6. No activity may start until its predecessor event is completed; in turn,no event may be considered complete until all activities leading into it have been completed.

<u>Rule 7.</u> A wide variation in the length of the arrows should be avoided. The angles between the arrows should be kept as large as possible; see Fig.(6).

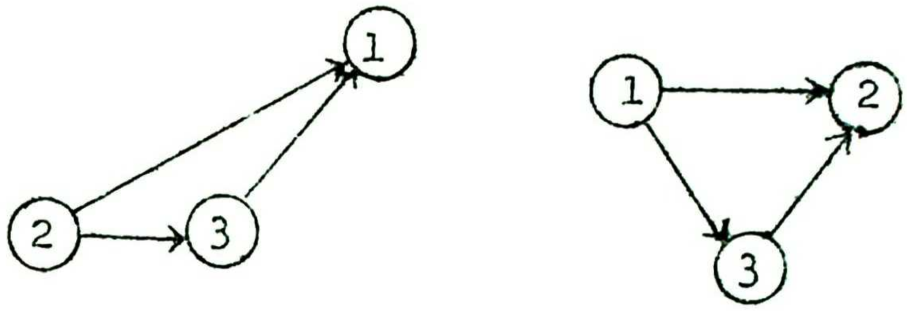


Fig.(6)

There should be left to right component in each arrow; Fig.(7).

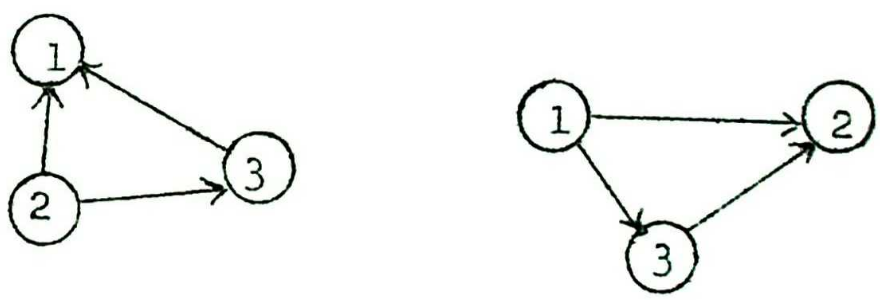


Fig.(7)

Unnecessary dummies should be avoided; see Fig.(8).

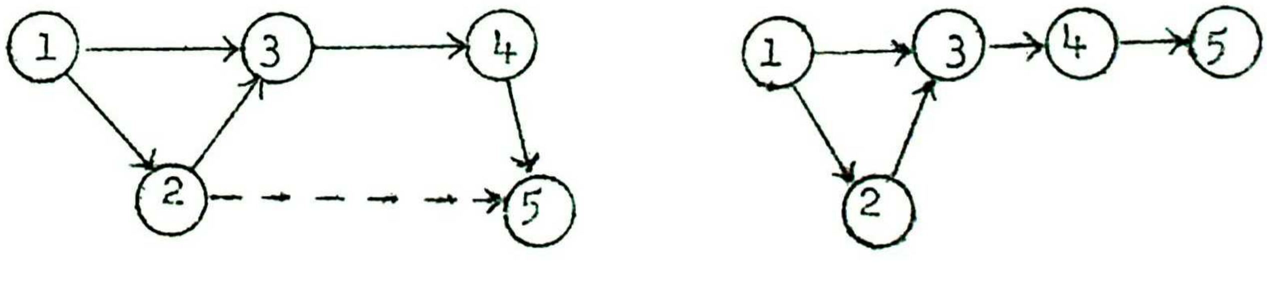


Fig.(8)

(ix) <u>Network Elements.</u>

A listing of diagrams, which appear again and again in arrow networks is given in Fig. (9), together with their interpretation.[1]

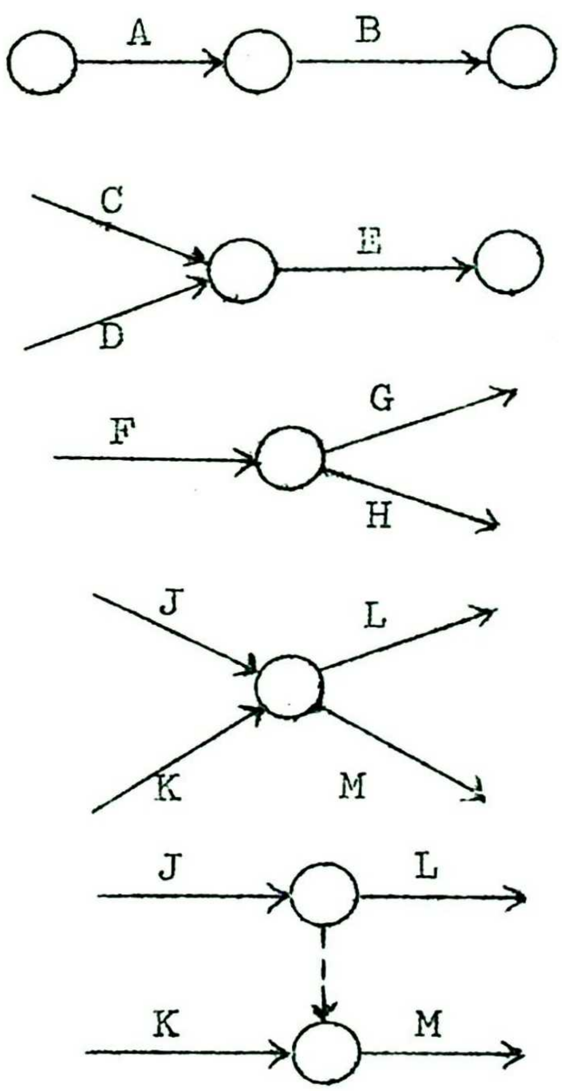
Network representation	Interpretation.
	Job B cannot start until job A is completed. E cannot start until both C and D are completed. F must be completed before either G or H can start. Both J and K must be completed before either L or M can start. Both J and K must be completed before M can start. L depends only on J not on K.

Fig. (9)

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1. L.R. Shaffer, J.B. Ritter, W.L. Meyer, <u>The Critical Path Method.</u> (New York, McGraw-Hill Book Co., 1963). p.9.

(b) Network or the Arrow Diagram.

The network is composed of a series of connected arrows to describe the interrlationship of the activities or events involved in a project.[1] The arrows are connected in a logical sequence and according to logical relationships to indicate the flow of work from the beginning till the end of the project.[2] The arrows usually flow from left to right, but without reference to a time scale. This becomes the basic working document for planning scheduling and control. In applying CPM/PERT to a project,arrow diagram is the first and most important phase.

A network provides the following.[3]

1. A disciplined basis for planning a project.
2. A clear picture of the scope of a project.
3. A method for evaluating goals.
4. A means of preventing omission of activities that naturally belong to the project.
5. A definition of the responsibilities of the various groups or departments involved.
6. An aid in refining the design of a project.

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1. James J. O'Brien, op.cit., p.14.
2. R.L. Martino, Applied Operational Planning, op.cit., p.17.
3. Water Resource Project Planning, op.cit., p.210.

To provide these, the network must be a technically accurate representation of the plan to be followed, and it must be intelligible to those required to examine it.[1]

(i) Network Construction.

A network may be drawn in two ways. One can start at the beginning of a project and draw the a activities which can follow immediately after the first activity has been completed, and so on until the final activity is reached.

Alternatively, one can start at the final activity and working backwards, draw in all the activities which must be completed before this final one can take place and continue in this way until the initial activity is reached.

Networks are usually drawn with the project start event in the left and project end event on the right.

(ii) Numbering the Network.

There are two ways of doing this, either randomly or sequentially. To number a network sequentially in ascending order, all of the network

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1. H.S. Woodgate, op.cit., p.47.

start events are located the lowest numbers in the range and then events are numbered progressively from the network start events to the network end events.[1] To obtain a number sequence in descending order, this procedure can be reversed by starting at the network end events and working back to the start events. However, networks often need alternation and it is tedious to renumber the whole network whenever additional event is added. The most compromise plan is to leave the event numbering until the last possible moment, number events sequentially and as evitable changes occur, introduce new events as random numbers.[2]

Alphabetic and/or numeric characters may be used in numbering the events.

(iii) Event Oriented Network.

An event oriented network is exclusively concerned with the achievement of events. In such a network each event is given a clear alphabetic description in addition to the event number. Event only networks are generally used in early stages of project planning, when the exact work content is not sufficiently defined to apply meaningful descriptions to specific activities.[3]

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1. James J. O'Brien, op.cit., p.22.
2. H.S. Woodgate, op.cit., p.66.
3. Dan A. Bawly and Joseph M. Dotan. Using PERT in Accounting Reports, Management Services. (July-Aug. 1970). p.31.

The statistical calculations concerned with the probability of achieving event scheduled dates are normally associated with event oriented network.[1]

(iv) Activity Oriented Network.

Activity oriented network is specifically concerned with activities and each activity has an activity number and carries a description. Activity-oriented networks are used extensively at the working level of project execution.

It is possible to construct and use a network which contains full information regarding both events and activities.[2]

3.4 The Critical Path Method (CPM).

CPM is a powerful, but basically simple technique for analysing planning and scheduling large complex projects.

The characteristics of CPM are,[3]

1. It is useful at various stages of project management from initial planning to scheduling and controlling the jobs.

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1. Robert W. Miller, op.cit., p.39
2. P.J. Burman, op.cit., p.124.
3. F.K. Levy and G.L. Thompson: The ABCs of the Critical Path Method, Harvard Business Review. (Sept.-Oct. 1963). p.108.

2. It displays the interrelations in the complex of jobs.
3. It is explainable to the layman by means of the project graph.
4. It pinpoints attention to the small subset of jobs that are critical to project completion time, thus contributing to more accurate planning and more precise control.
5. It enables the manager to study the bottlenecks that might result from shortening certain critical jobs.

Because of the above characteristics of CPM, especially its intuitive logic and graph appeal, it is an aid to management, which can find wide appreciation at all levels of management. The underlying simplicity of CPM and its ability to focus attention on crucial problem areas of projects make it an ideal tool for the manager.

(a) Time Estimates.

The time dimension used in CPM is the project time. Any convenient time unit can be used, but it must be consistent throughout the network. The unit usually used is working days. In estimating activity-time durations, the approach is to consider the amount of work to be done and the crew size anticipated and to convert this into a reasonable project time requirement.[1]

Time estimates are important as they form the basis of the analytical operation carried out on the network. Absolute accuracy is virtually impossible to achieve, and it is inevitable that some individual time estimates will contain errors. Dividing projects into many separate activities affects some localization of these errors by offering a large number of smaller operations to the estimator.[2]

(b) Time Analysis of the Network.

Time analysis gives management the ability to plan projects on a time basis and to ensure that sound schedules are prepared. Time analysis is important, because a finite time limit is a common characteristic of every project.

Activities and events involved in construction of a house are given in table I.

We can analyse the logical sequence of these activities or decide what other activities must necessarily be completed before it can be started.

Obtaining bricks, obtaining roof-tiles and preparing foundation can be done concurrently. Roof can

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1. James J. O'Brien, op.cit., p.37.
2. H.S. Woodgate, op.cit., p.87.

Table I

Activity	Activity Description	Starting Event	Finishing Event	Estimated days for completion.
A	Obtain Bricks	1	3	3
B	Obtain roof-tiles	1	5	12
C	Prepare foundations	1	2	7
D	Erect Shell	3	4	10
E	Construct roof	5	7	4
F	Lay drains	2	6	7
G	Wiring	4	7	10
H	Plastering	7	9	6
I	Plumbering	6	7	12
J	Flooring	7	10	5
K	Landscaping	8	10	2
L	Painting and cleaning	10	11	6
M	Doors and Fitting	9	10	2
N	Lay path ways	6	8	2

Source : F. de P. Hanika, New Thinking in Management. (London, Hutchinson & Co. Ltd., 1965), p.98.

be constructed after the roof-tiles are obtained. The drains cannot be laid before the foundations are prepared. Plastering can start after wiring. Plastering and flooring can start concurrently. Plumbering and laying path ways can also start concurrently. After analysing in this way we can draw the network diagram for the construction of a house, according to the rules mentioned earlier. The resulting network diagram is shown in Figure (10).

The first event on the network is allocated an earliest event time 0. Then the earliest event times of the other events are computed by moving forward till the end event. The latest event time is computed by starting from the end event, giving it the same time as the earliest event time, and moving backward till the first event. (See Figure 10).

We can also compute earliest start and finish time, latest start and finish time, total float, free float and independent float. The results are shown in table II.

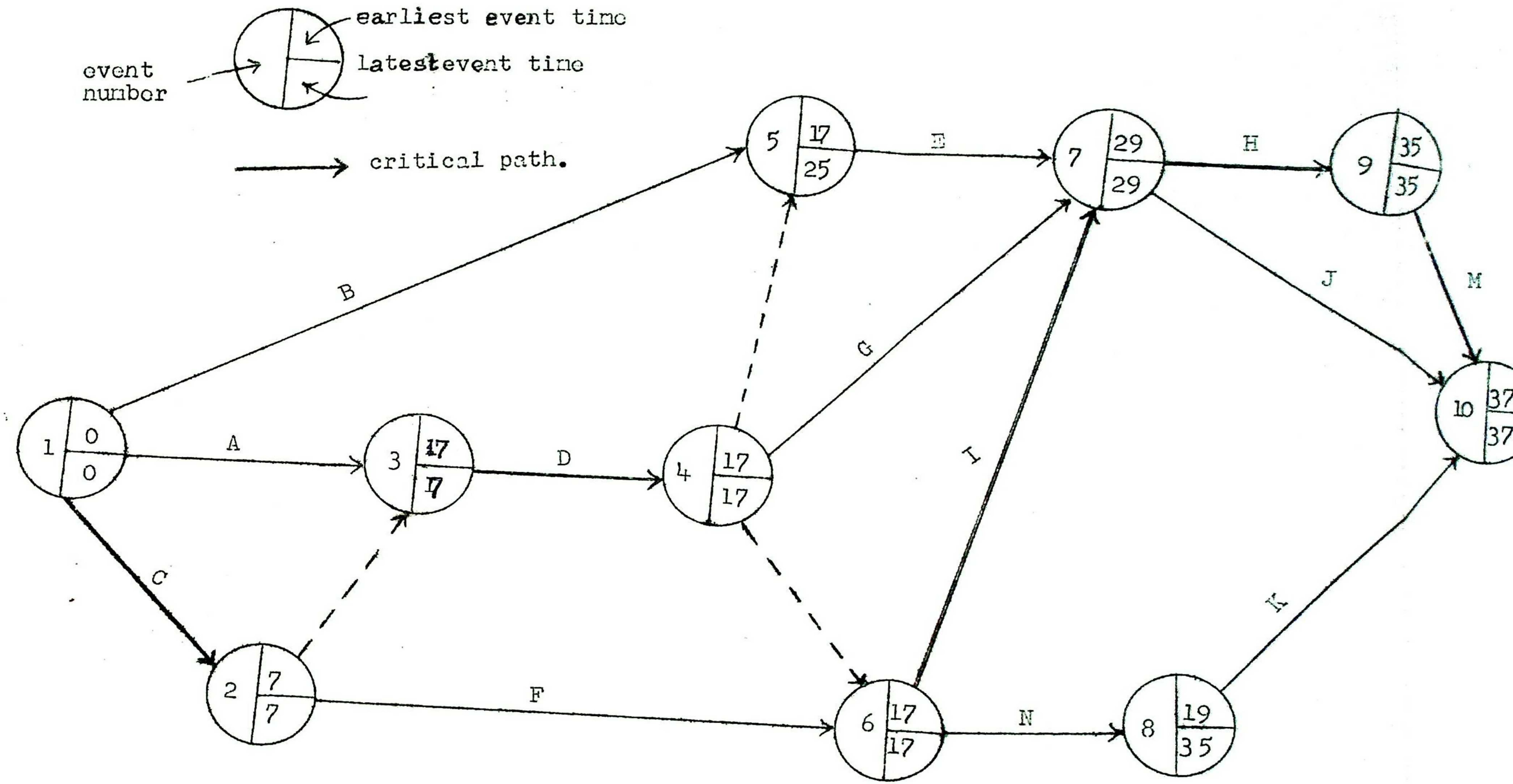

Fig. (10) Network diagram for construction of a house,

Source : F. de P. Hanika, <u>New Thinking in Management.</u> (London, Hutchinson & Co. Ltd., 1965). p.98.

Table II

Results of Time Analysis

Activity	Preceding event	Succeeding event	Activity description	Activity Duration	Early Start	Early Finish	Latest Start	Latest Finish	Floats: Total float	Floats: Free early	Floats: Free late	Floats: Independent	Critical path
C	1	2	Prepare foundations	7	0	7	0	7	0	0	0	0	
A	1	3	Obtain bricks	5	0	5	2	7	2	2	2	2	
B	1	5	Obtain roof tiles	12	0	12	13	25	13	5	13	5	
F	2	6	Lay drains	7	7	14	10	17	3	3	3	3	
DUMMY	2	3	dummy	0	7	7	7	7	0	0	0	0	
D	3	4	Erect shall	10	7	17	7	17	0	0	0	0	
DUMMY	4	5	dummy	0	17	17	25	25	8	0	8	0	
DUMMY	4	6	dummy	0	17	17	17	17	0	0	0	0	
G	4	7	Wiring	10	17	27	19	29	2	2	2	2	
E	5	7	Construct roof	4	17	21	25	29	8	8	0	0	
I	6	7	Plumbering	12	17	29	17	29	0	0	0	0	
N	6	8	Lay path ways	2	17	19	13	35	16	0	16	0	
H	7	9	Plastering	6	29	35	29	35	0	0	0	0	
J	7	10	Flooring	5	29	34	32	37	3	3	3	3	
K	8	10	Land scaping	2	19	21	35	37	16	16	0	0	
M	9	10	Doors & fittings	2	35	37	35	37	0	0	0	0	
L	10	11	Painting and cleaning	6	37	43	37	43	0	0	0	0	

Source : Computed from the Figures given in F de. P. Hanika, New Thinking in Management. (London Hutchinson & Co. Ltd., 1965). p.98.

The results of time analysis in table II can be briefly explained as follows.[1]

(i) Earliest Start.

This is the earliest date on which the activity can commence due to the limitation of previous activities. It is the same as the earliest event time. This value is taken directly from the network diagram.

(ii) Earliest Finish.

This is the eafliest date on which it is possible to finish the activity due to the restrictions of all previous and parallel activities. It is obtained by subtracting the duration of an activity from its earliest start time.

(iii) Latest Start.

This is the latest date on which it is possible to start the activity without delaying the completion date of the whole project. It is obtained by adding the activity duration to the latest finish date.

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1. The definitions and formulas included in this explanation are adapted from -
P.J. Burman, op.cit., p.86.
K.G. Lockyer, op.cit., p.41.
H.S. Woodgate, op.cit., p.151.
James J. O'Brien, op.cit., pp.38-41.
B Van Der Veen, Introduction to the Theory of Operational Research. (Netherlands, N.V. Philips Gloeilampenfabrieken Eindhoven, 1967). pp.148-151.
David I. Cleland and William R. King, op.cit., pp.340-345.

(iv) Latest Finish.

This is the latest date on which it is possible to finish the activity without jeopardizing the completion date of the whole project. It is the same as latest event time shown in the network.

(v) Total Float.

The time by which an activity may be delayed without effecting the final completion date of the project. This is the maximum time available to perform the activity. If the total float is zero, the activity is critical.

Total float for an activity = latest event time of succeeding event - earliest event time of preceding event - activity time.

e.g. Total float for activity (1,5) = 25 - 0 - 12

= 13. days

(vi) Free Float-early.[1]

This is the amount of time by which an activity may be delayed without affecting any other activity, when any operation is carried out at the earliest possible point in time. If it is negative, it is taken as

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1. Free early float is also labeled free float when a single free float is used. Hence interfering float can be computed by subtracting free float from total float. But it is not widely used.

zero.

Free float early for an activity = Earliest event time of succeeding event - earliest event time of preceeding event - activity time.

e.g. Free float early for activity (1,5) = 17 - 0 - 12.
= 5. days.

(vii) Free float-late.

This is the amount of leeway available to an activity when every operation is carried out at the latest possible point in time. If this float is negative it is taken as zero.

Free float-late for an activity = latest event time of succeeding event - latest event time of preceeding event - activity time.

e.g. Free float-late for activity (1, 5) = 25 - 0 - 12
= 13 days.

(viii) Independent Float.

It is the maximum amount of spare time available to an activity, no matter where the activity's preceeding and succeeding events are placed in time. If this float is negative it is taken as zero. i.e. there is no independent float.

Independent float for an activity = Earliest event time of succeeding event - latest event time of preceeding event - activity time.

e.g. Independent float for activity (1,5) = 17 - 0 -12 = 5 days.

There can be negative value for total float.[1] When an event latest date becomes earlier than the earliest date then it will give a negative total float. Negative total float indicates the amount by which the activity is behind schedule or the amount of time which must be made up by one means or another, to meet the target date.[2] The most useful types of floats have been found to be the total and free floats. These measures become particularly important when limited resources have to be allocated within project.

The critical path is indicated by a series of events where the earliest event time and latest event time are equal, see Figure (10). It is also a series of activities which have zero floats, see table II. The series of activities in the critical path are, 1-2, 2-3, 3-4, 4-6, 6-7, 7-9, 9 - 10 and 10 - 11. The total project

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1. When there is negative float, the critical path in a network is that path which has least float.
2. P.J. Burman, op.cit., p.101.

time is given by the length of this path. It is (43) days, see Figure (10).

3.5 PERT (Program Evaluation and Review Technique).

Since the concepts and methods embodied in PERT are the same as those described for CPM, the discussion of PERT will cover only the major differences of these two.

Uncertainties concerning the nature of specific jobs that must be done, pose serious problems as to the validity of any estimates of time or costs. To handle situations like this, a statistical approach has been developed using three estimates of time for each activity.

PERT defines the three time estimates as follows.[1]

T_o = Optimistic duration : the time required if nothing at all goes wrong with the performance of the activity. There should be about one-in-a- hundred chance that this duration will be achieved.

T_m = Most likely duration: the time which would most often be achieved if the activity were

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1. These definitions are adapted from
R.C. Maltino, op.cit., p.37.
P.J. Burman, op.cit., p.73-74.
Richard I. Levin and Charles A. Kirkpatrick, op.cit., p.41.

carried out repeatedly. It is the same as CPM estimate.

T_p = pessimistic duration : the time required if everything goes wrong with the performance of the activity. There should also be about a one per cent chance of this occurrence.

This is the basis of the PERT system, whose fundamental assumption is that, if an activity is carried out an infinite number of times, the actual times taken would form a frequency distribution of the Beta type. The optimistic and pessimistic durations would give the tails, and the most likely duration, the mode of the distribution.

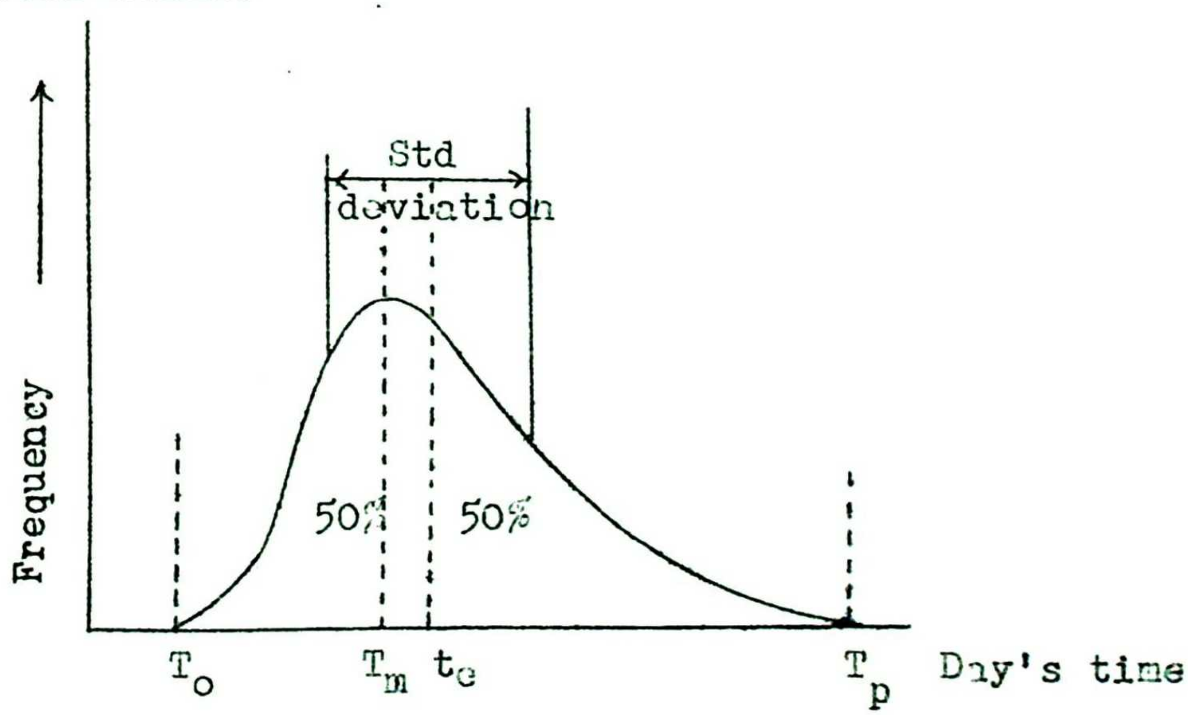

Fig. (11). Illustration of beta distribution.

Source : P.J. Burman, Precedence Networks for Project Planning and Control. (London, McGraw-Hill Book Co. Ltd., 1972), p.74.

It was further assumed that a fair approximation of the expected duration (t_e) would be given by the formula :

$$t_e = \frac{T_o + 4\ T_m + T_p}{6}$$

(t_e), the mean or the expected time represents a point where there is a 50% chance that the actual activity completion date will be earlier or later than (t_e).

The standard deviation (σ) or its squared version variance (σ^2) represents a measure of the dispersion or spread of the curve. Standard deviation and variance are computed by the following formulas[1]:

$$\sigma^2 = \left(\frac{b - a}{b}\right)^2$$

$$\sigma = \frac{b - a}{b.}$$

(a) PERT Computations.

Before the computations are made, the following terms should be noted.

(i) T_E (Cumulative Expected Time for an Event).

T_E represents the sum of all the individual t_e's along the path leading to that event.[2] The longest path leading into anyone event is the determining factor.

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1. R.L. Martino, op.cit., p.37.
2. Robert W. Miller, op.cit., p.45.

The resulting T_E value them represents the earliest time that event can be completed. It is the same as the earliest event time in CPM.

(ii) T_L (Latest Allowable Time.)

The latest allowable time for each event can be determined by proceeding backward from the earliest completion date, subtracting expected times of the events. The (T_L) represents the latest date that an event can occur and not jeopardize the project completion date.[1] It is the same as latest event time in CPM.

(iii) Slack.

Slack is the time flexibility available to management in scheduling, and is defined as (T_L - T_E). If T_L is earlier or lesser than T_E, than negative slack exists, and the completion of the project is in jeopady. It can be remedied in two ways. First a portion of the resources can be withdrawn from non-critical activities and allotted to critical activities. Second, management can increase the overall level of resources devoted to the project.

The path with the most negative slack or the least positive slack is necessarily the longest path - the critical path.[2]

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1. Ibid., p.42.
2. David I. Cleland and William R. King, op.cit., p.347.

(iv) Illustration.

A network diagram with three times estimates (days) are given in Figure (12). From this network, T_E, T_L and slack can be computed, see table III.

A series of events which has the least slack or whose T_E and T_L are equal, ie., 01, 02, 04, 05, 09, is the critical path see Figure (12) and Table III.

Table III

Event number	Critical path	T_E	T_L	Slack
01	*	0	0	0
02	*	14	14	0
03		11.3	19.4	8.1
04	*	14	14	0
05	*	35.2	35.2	0
06		29	45.6	16.6
07		49.2	56.8	
08		30	57.2	27.2
09	*	66	66	0

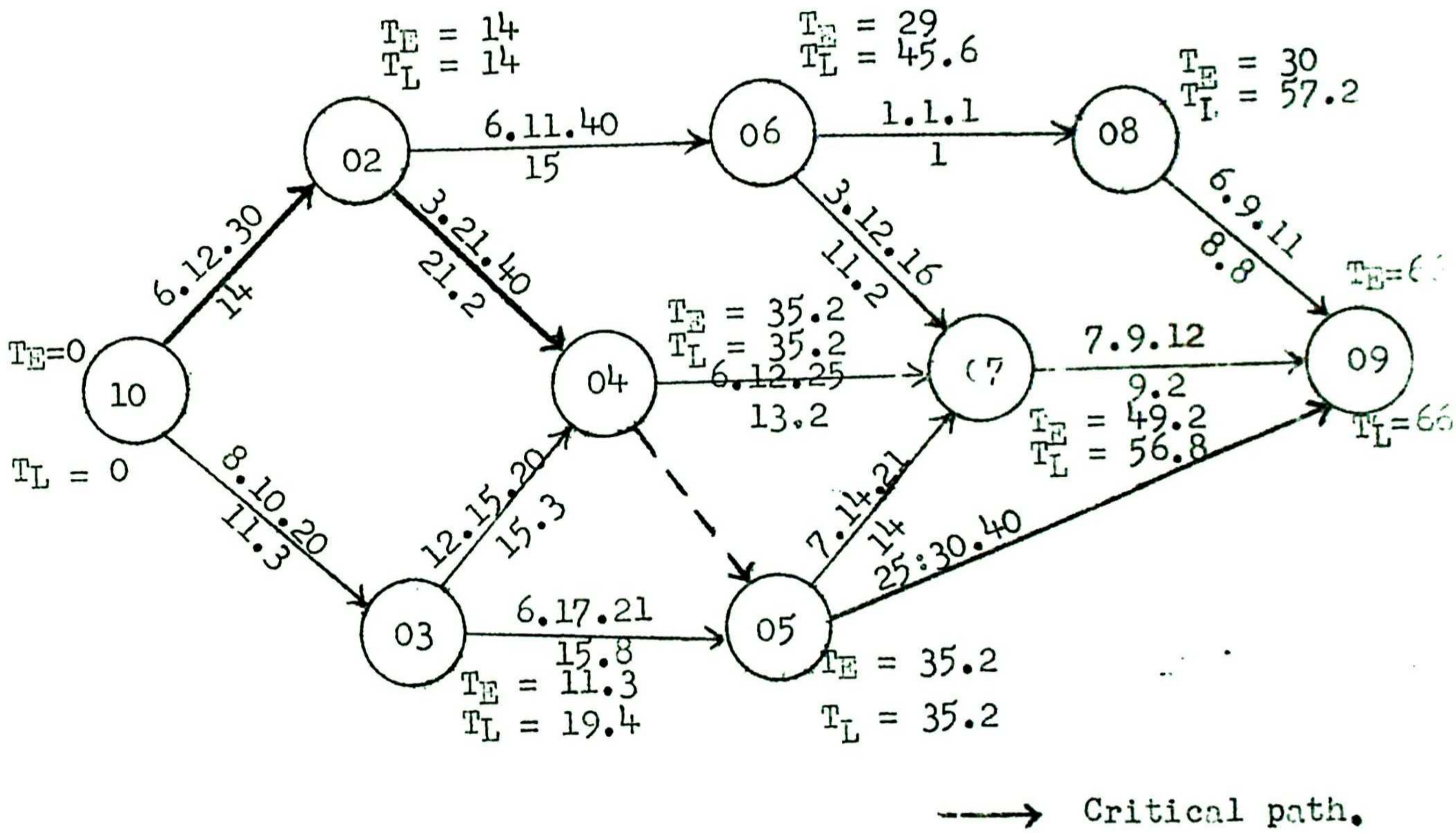

Figure (12). T_E and T_L calculations.

Source : Albert Battersly, Network Analysis. (London, Macmillan and Co., Ltd., 1967). p.126.

Probability of Meeting Scheduled Date.

A scheduled date on a project represents a desire to achieve a particular event by a predermined time.[1] The probability of meeting the scheduled date can be determined by using the concepts of slack and standard deviation of an activity. On the basis of the Central Limit Theorem , one can conclude that the distribution of possible completion times around T_E for terminating events may be approximated by the normal or bell-shaped distribution.[2]

In this situation, the probability of achieving a T_s is found by expressing the difference between T_S and T_E in units of σ[3].

i.e. $$Z = \frac{T_S - T_E}{\sigma}$$

Z = probability factor of meeting the required completion time.

T_S = scheduled date.

T_E = cumulative expected date.

σ = Standard deviation.

This will yield a value for the probability of accomplishing T_S by use of the normal distribution table.

The network in Figure (12), shows that total duration is (66) days. If the scheduled completion date is given to be (60) days, the probability of meeting this date can be computed as follows.

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1. Edward C. Bursk and John F. Chapman, op.cit., p.116.
2. Robert W. Miller, op.cit., p.54.
3. Ibid. p.55.

The standard deviation, expected time, and variance are computed for each activity in the network and shown in table V.

Table V

Activity	Standard deviation $\sigma = \frac{b - a}{6}$	expected duration $t_e = \frac{T_o + 4T_m + T_p}{6}$	Variance σ^2	Critical Path
01 - 02	4	14.0	16	*
01 - 03	2	11.3	4	
02 - 04	6.17	21.2	33.07	*
02 - 06	5.67	15.0	32.15	
03 - 04	1.33	15.3	1.79	
03 - 05	2.50	15.8	6.25	
04 - 05	.0	0	0	*
04 - 07	3.17	13.2	10.05	
05 - 07	2.33	14.0	5.43	
05 - 09	2.50	30.8	6.25	*
06 - 07	2.17	11.2	4.71	
06 - 08	0	1.0	0	
07 - 09	0.83	9.2	.67	
08 - 09	0.83	8.8	.67	

Total variance along the critical path

$$= 16 + 38.07 + 6.25$$

$$= 60.32$$

Standard deviation of the final event = $\sqrt{60.32}$ = 7.8

T_s = 60 days (given)

$$\therefore \quad Z = \frac{T_S - T_E}{\sigma} = \frac{60 - 66}{7.8} = -0.77.$$

Refering to normal curve table we find its corresponding percentage of area under the normal curve to be about 22%. Therefore the probability that project duration will not exceed (60) days is 22%. It will be exceeded is therefore 78%.

PERT is viewed as a major step forward for the management of nonrepetitive or one time through programs. Because time prediction and performance data are available from PERT in a highly ordered fashion, managers are given the opportunity to concentrate on the important critical path activities.

Many individuals in different locations or organizations can easily determine the specific relationship of their efforts to the total task requirements of a large program. PERT is strongly oriented to forecasting the ability to accomplish future events on schedule.[1]

3.6 Main Differences Between CPM and PERT.

In the CPM technique only a single elapsed-time estimate is made. With this approach, the problem of uncertainty in time estimate is disregarded. The single time estimates work very well in such applications where there is a large amount of prior history on comparable activities, or where time and cost of various jobs could be estimated with a reasonable amount of accuracy, or where standard exists for individual activities.[2] Thus CPM is said to be a deterministic model.

The three time-estimating approach of PERT constitutes one of its most important features, since it beings the problem of uncertainty out in the open.[3] Since PERT analyses statistically, and contains explicit recognition of uncertainty, it is said to be probabilistic. It is often cited that PERT is best suited for projects where more uncertainties are to be encountered.

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1. Richard I. Reevin and Charles A Kirkpatrick, op.cit., p.30.
2. William R. King and T.A. Wilson. Subjective Time Estimates in Critical Path Planning, Management Science. (Jan, 1967), p.310.
3. R.L. Martino, op.cit., p.3.

The three time-estimate system of estimating durations does offer a means of compensating for or anticipating delays and is from this point of view preferable to the rigidity of the one time-estimate system.[1]

However, in recent years, the differences have tended to disappear. Both techniques are equally applicable to planning, monitoring and controlling, and both are equally applicable to any kind of project which is a one time effort.

3.7 The Use of the Computer in Project Management with Reference to CPM/PERT.

In applying CPM/PERT in project management, a computer should be used, whenever it is needed or whenever its use is economically justified.[2]

There are distinct advantages to be gained from using a computer for the analysis of the network. This is especially true for networks of more than one hundred activities where a manual analysis becomes a protected operation. A network requiring days of manual calculation can be analysed on electronic computer in a few minutes.

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1. P.J. Burman, op.cit., p.277.
2. R.L. Martino, Critical Path Networks, op.cit., p.3.
   ---- Resources Management, op.cit., p.134.

Computers tend to be more accurate than their counterparts. Repetitive manual calculations are seldom error-free and the nature of the CPM/PERT calculations mean that an uncorrected early error can invalidate the whole calculation.[1] Computers on the other hand are built to carry out millions of calculations without a single error.

(a) The Program.

The total number of instructions required in order to obtain the desired results is called a program.[2] The computer learns from it instantaneously how to do a certain set of calculations. For example, producing a schedule or report from a network. All computers provide substantial programs for project planning and control techniques (i.e. CPM and PERT) which are readily available, and it is extremely rare that a special program needs to be written.[3] Thus CPM/PERT is usually handled by programs.

Each company's programs for CPM/PERT technique have their own individual characteristics and it is necessary for a prospective user, to study the manuals of his particular choice of programs in order to gain insight into the requirements and capabilities of the chosen

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1. H.S. Woodgate, op.cit., p.138.
2. L.R. Shaffer, op.cit., p.171.
3. Report of Seminar-cum study tour....... op.cit., p.183.

tool.

(b) The Input.

The network once drawn must be translated into a form which the computer can deal. The first step therefore is to prepare a data list of the items included in the network. From this list the input for the computer is prepared. Coding is the operation of writing on the input documents the information to be read by the computer. This must be prepared in accordance with the program specification, and needs to be carefully checked by the user of the computer before the cards or tapes are punched from it.[1] The input data for processing are then submitted to the computer.

(c) The Output.

The usual format of printout is tabular. It is also possible to have the computer print its results in bar chart format. Typical reports available for CPM/PERT usually includes :

1. Time analysis reports in various sequences.
2. Resource analysis reports.
3. Cost analysis reports.
4. Bar charts and graphs for time, resource and cost.

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1. Albert Battersby, op.cit., p.134.

(d) Salient Features of the Computer.

It is often advantageous on large networks to have the analysis presented in several different sequences for different purposes. Computers can carryout the necessary sorting and selecting processes very quickly, thus often making the results more usable.[1]

It is usual for a computer before analysing a network to carry out extensive checks on the data supplied and on the validity of the network.[2] It will check that each item of activity and event data relates to the network being processed and that information has not been wrongly prepared for computer processing. It will also check the logic of the network, these checks being mainly to detect odd ends or dangling arrows and network loops.

A computer not only carries out these checks but identifies the errors as precisely as possible and prints this information so that the correction can be made without delay.[3] Any error in network logic if undetected can render the calculations useless.

Some arguements against the use of the computer are :[4]

1. doing the arithmetic by hand gives one an insight into the project which delegation to a machine cannot provide.

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1. Report of seminar ....,op.cit., p.105.
2. Ibid.,p.186.
3. K.G. Lockyer, op.cit., p.112.
4. Albert Battersby, op.cit., p.126.

2. Manual work reinforces the planner's knowledge.
3. Time and effort must be spent in preparing the data for the computer.
4. The delay in getting data to and from the computer especially when an outside machine is used, may interfere with control of the project.

Some favourable arguments are.[1]

1. The arithmetic in a large network is tediously repetitive and should not be inflicted on human beings.
2. A modern computer produces a virtually perfect result given the correct input.
3. Many alternative plans can be considered and the schedules can be revised easily at short notice.
4. Although computers are complicated machines, one needs only to know how to use them, not how they work.

3.8 Prerequisites for the Application of CPM/PERT

There are certain prerequisites for the successful implementation of CPM/PERT system. These factors can be stated as follows.

(a) Operating System.

Adequate delegation of authority and responsibility from higher to lower levels in the system

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1, Ibid., p.127.

should be made in order to avoid delays and cost increase.[1] Tectical decisions should preferably be delegated to individuals as far down the organizational hierarchy as possible.[2] These decisions include operational problems, which may be of day by day nature, such as allocation of resources, for instance manpower, and alleviation of delays.

Planning and controlling projects through CPM/PERT demands good management discipline which includes, strong management control, good cooperation between executive and technical staff, and good management reporting systems.[3] If this discipline is lacking, networks will not be used effectively.

The top management should be oriented and became acquainted with these techniques and with their capabilities in saving time, cost and resources.

The individuals concerned with CPM/PERT application must be qualified enough to be knowledgeable in the mechanics of CPM/PERT including network development, calculations, analysis and application. At least one member of the team should be familiar with data processing operations.

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1. H.J.M. Lombaers, op.cit., p.59.
2. Ibid., p.60.
3. P.J. Burman, op.cit., p.300.

The functions of the CPM/PERT technique personnel would be.[1]

1. Maintaining networks.
2. Preparing input data.
3. Attending computer runs and correcting errors.
4. Analysing output.
5. Preparing management information.
6. Assisting managers in identifying problem areas and suggesting alternative solutions supported by available data.

(b) Provision of Information and Controlling.

This system is mainly concerned with gathering of information and followup and control of project implementations. Gathering of information is related to preparation and planning of the project and programming of implementation.

Information regarding preparation for programming of implementation are, specification of machinery and equipment, raw materials, preparation of tenders, information on suppliers, project activities according to selected levels of detail, the logic of strategy, activity sequential relationships, methods of performing the project, durations, network technique

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1. Peter P. Schoderbek, op.cit., p.404.

used, resulting time schedules, critical and sub critical paths and available floats and the like.[1]

By using these information, the logic of strategy already adopted should be reviewed and adjusted, and project implementation network should be updated for further use as a control tool for project implementation.[2]

In the process of follow-up and control, actual performance is to be compared with estimates in terms of time, resources and their rate of utilization and costs.[3] Delays and their costs should be determined together with control factors. Rough estimates of additional funds and resources required to complete the project and any increase of project duration may be worked out.[4] Alternative corrective actions are then to be proposed for decision making. On the basis of these proposals, a review and modification of the network plan should be made whenever needed.

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1. D.G. Malcolm, J.H. Rosebloom, C.E. Clark & W. Frazer. Application of a Technique for Research and Development Program Evaluation, Operations Research, (Sept.-Oct., 1959). p.650.
2. Ibid., p.665.
3. J.W. Pacock, PERT as an Analytical aid for Programming Planning : Its payoff and Problems, Operations Research, (November - December, 1964). p.901.
4. Ibid., p.902.

(c) Communication.

The main function of communication system is to transmit precisely, information and directives to the right person at the right time. The transmission of information should take place upwards from lower to higher levels as well as side ways at the same level within the organization.

The communication should also take place as well as from the system to other bodies outside the organization which are concerned with different aspects of the project.

Information could conveyed verbally as well as in writing, but they should be generally written. Verbal communication may take place at meetings held between project personnel.

Reports are most widely used form for written communication. Different types of reports including information concerning activity scheduling, data, available total floats by time period, will give the analyst the best opportunity to solve problems.[1] Reports should comprise only the information required by the recipient of the report.

As the information moves upwards it should be less detailed. It is of essential importance that

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1. J.W. Pocock, op.cit., p. 903.

those concerned in preparation of reports at the lower level are given directions as the information to be collected and developed, and the form of reports required.[1]

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1. H.J.M. Lombares, op.cit., p.62.

CHAPTER 4.

Conditions of CPM/PERT Application and Research Procedure.

CPM/PERT technique is a network-based technique that has been developed to aid management in planning, scheduling and controlling complex projects.

The present study is a search into the feasibility and application of this technique to conditions in the Burmese industrial environment. The first part of this chapter presents the factors which influence directly on the pattern of project planning and control work in Burma. The second part deals with the research procedure of CPM/PERT application followed in this study.

4.1 Factors Influencing the Functions of Project Management in Burma.

Specific factors influencing the project management functions in Burma can be generally classified into three main groups, (See Fig.13) which are :

(a) Conditioning factors.

(b) Organizational factors, and

(c) Operational factors.

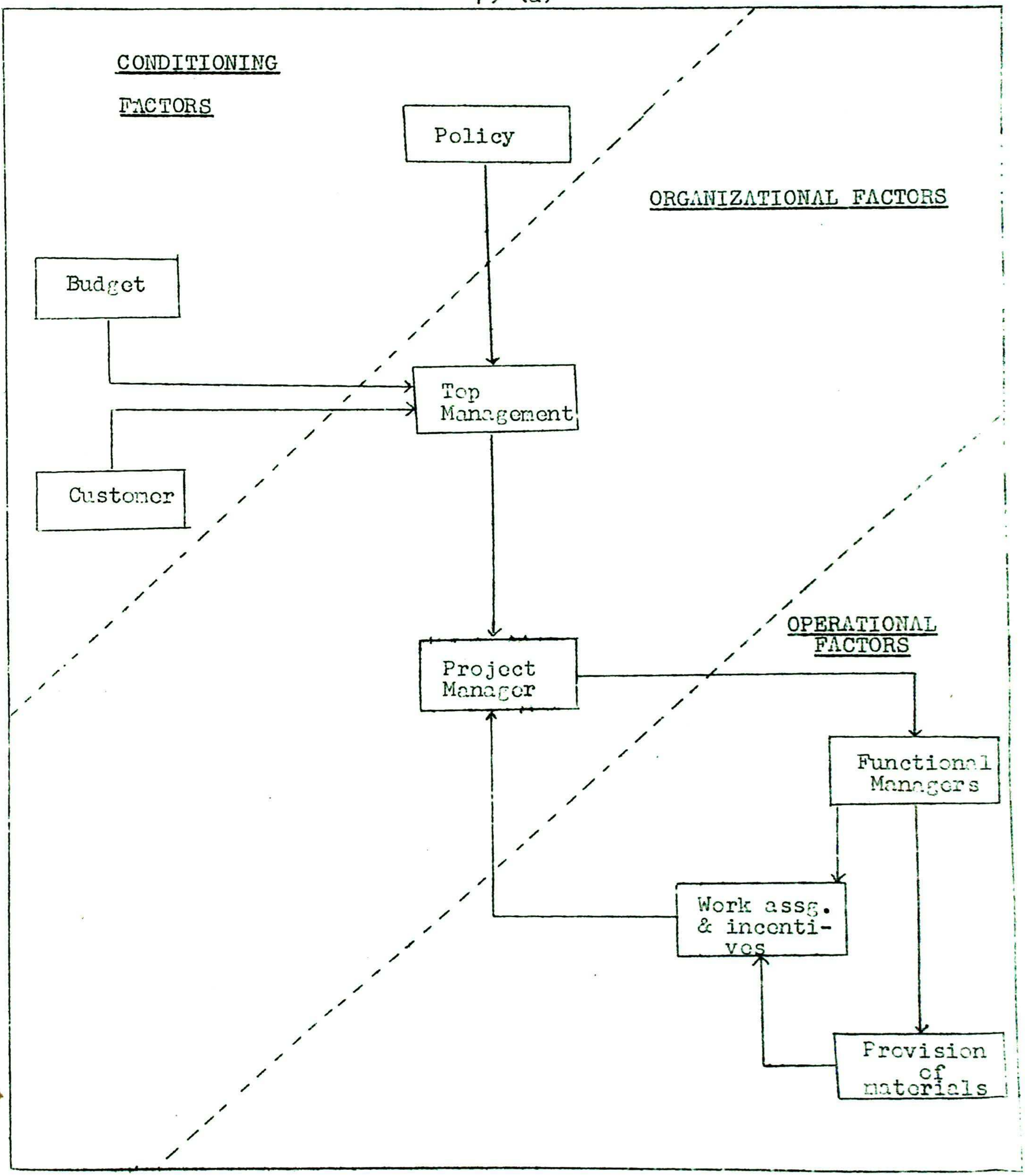

Fig.(13). A simplified diagram showing the influencing factors of project management.

By and large, conditioning factors include government policy towards the development programs, the budget system, and the demand of the state enterprises, which can be taken as the "customer organizations."

The organization set up of the enterprise undertaking the projects is the determining factor of the project organization. However, the top management who has full authority for the establishment of the project and the project manager who is responsible for the successful implementation of the project are the core of the project organization.

The main tasks of actual implementation of the project are determined by assignment of work and incentives and provision of materials supervised by functional managers.

(a) Conditioning Factors.

The state enterprises, desiring to order the job (for example the Burma Five Star Line Corporation) must formulate the project proposal according to the set procedures. This procedure is laid down by the government with its policies on industrial development and general administration.

The process of project formulation and approval must go through the budget system before it is sanctioned. Hence, the government policy and the budget system are the main factors of consideration for the customer enterprise to propose a project, which later has to be implemented by another project organization (for example Sinmalike Dockyard Corporation).

(i) Policy of the Government.

The government has laid down policy guidelines toward economic development for every aspects of the economy, such as industry, finance, trade, labour, construction, communication, transport, agriculture, cooperatives, natural resources, etc. Some salient factors included in the short and long term general economic policy of the government are as follows :[1]

1. To run the state enterprises on a commercial and a more competitive basis, so as to increase their efficiency. To fix profit as an indicator of the success of the business.
2. To introduce reward and punishment system, piece-rate system and material incentive as much as possible, so as to increase the productivity.

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1. Short Term and Long Term Economic Policy of the Burma Socialist Program Party. 2nd ed. Rangoon, Burma Socialist Program Party, 1973. (in Burmese). pp.29-50.

3. To eliminate the system of classifying the workers as permanent and temporary and to give equal rights to every workers. To increase the wages of workers according to their productivity and to narrow the gap of difference in income among the government employees. To reduce the unemployment level. Peoples' Workers' Councils are to organize and persuade the workers to have interest in work and to fulfill their duties promptly.
4. To increase the rights of the supervisors of the government enterprises so as to maintain "different levels of taking responsibility". To substitute qualified and skilled supervisors, for those who cannot manage the enterprise efficiently and effectively.
5. In accelerating the national economy with development plans, financial resources are to be allocated in the most effective and efficient manner, and the alloted funds are to be distributed from the Burmese Economic Banks. Thus state enterprises have to open accounts at the banks for financial transactions.
6. State enterprises which depend largely upon foreign raw materials are to look for new techniques and methods so that they can rely on local made materials.

Government policy is mostly reflected in decisions made at organizational and operational levels. For example, decisions concerning purchasing of raw materials, financial assistance for the government enterprises and departments, evaluation of work, and appointment of workers are within the limits of the government policy.

What is evident in most of the cases is that, meetings and seminars of the individuals participating in the project implementation are held most often to evaluate work progress and to take corrective actions; the financing of the government enterprises is through the budget system; new schemes are introduced (eg. Bonus system, piece-rate system) only when they are in accord with the policy; workers are appointed temporarily on salary basis; and raw materials are procured by the approved tender system from any country with low price and high quality.

But it seems that most state enterprises still cannot operate effectively as stated in the policy guide-lines. For example, some state enterprises still cannot run on commercial and competitive basis, and reward and punishment system, material incentive system, transfer of rights and responsibility to supervisors, are still in the process of execution.

(ii) The Budget System.

Before 1965, government corporations' expenses were financed by the Union Consolidated Fund, and they had been subject to the budget allotment approved by the Pyithu Hluttaw since its establishment in March 1974. Union Consolidated Fund was operated as follows. All receipts were to be deposited and they could not be spent by the state enterprises depositing them. All expenditures were drawn within the drawing limit given quarterly out of their annual budget. All new projects undertaken by the state enterprises had to be approved by the economic committee of the government and were financed through the Union Consolidated Fund.

As all the government corporations are to run on the commercial basis, a new system has been introduced for them, starting from 1975. According to this system, the corporations are provided with a certain amount of working capital depending upon their profit and loss. Each corporation has to open current account at the banks with the working capital as the opening balance. For each financial year, the corporations prepare the required budget(including foreign exchange)for their work programs, and apply for budget sanction. The budget includes current expenditures and capital expenditures. When the budget allotment is approved by the Pyithu Hluttaw, the Corporations can draw the approved amount of current expenditures from their current accounts whenever necessary.

The initial working capital provided by the government is to be repaid depending upon the financial conditions of the corporations.

All the incomes of the corporations must be deposited in their current accounts. If the corporations have losses, a certain amount of working capital will be required further. In this case, the corporations are provided with loans from the banks with a certain amount of interest.

As for the capital expenditures, (eg. for new projects, replacements, extensions) separate accounts for each corporation are opened at the banks, and the required amount is drawn from these accounts, subject to the approved budget allotment. At the end of the financial year, the balances of these accounts are surrendered to the government.

Other state enterprises, government departments and organizations are financed by the Union Consolidated Fund. When the budget allotments of the state enterprises, government departments and organizations are approved by the Pyithu Hluttaw, they draw the required amount from the Union Consolidated Fund. All the incomes of the state enterprises and government departments must be deposited in the Union Consolidated Fund.

As for the foreign exchange, even after its allotment is approved, the corporations, and departments have to apply again for the permission to spend whenever necessary.

All new projects undertaken by the corporations have to be approved by the Economic Committee of the Council of Ministers, and once it is approved, the financing of the projects will be done by the state budget.[1] Going concern projects need not be submitted to the Economic Committee of the Council of Ministers for approval, (For example shipbuilding projects undertaken by the SDC or IWTC). Such corporations have only to apply for the required budget for their work programs every financial year. The procedure for formulation and implementation of new projects is shown in Figure (14). Different levels have to communicate upward and downward repeatedly from the time of getting approval for the new projects up to the

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1. Financing of new projects is also done by foreign aids or foreign loans besides the state budget. It is not discussed in this paper.

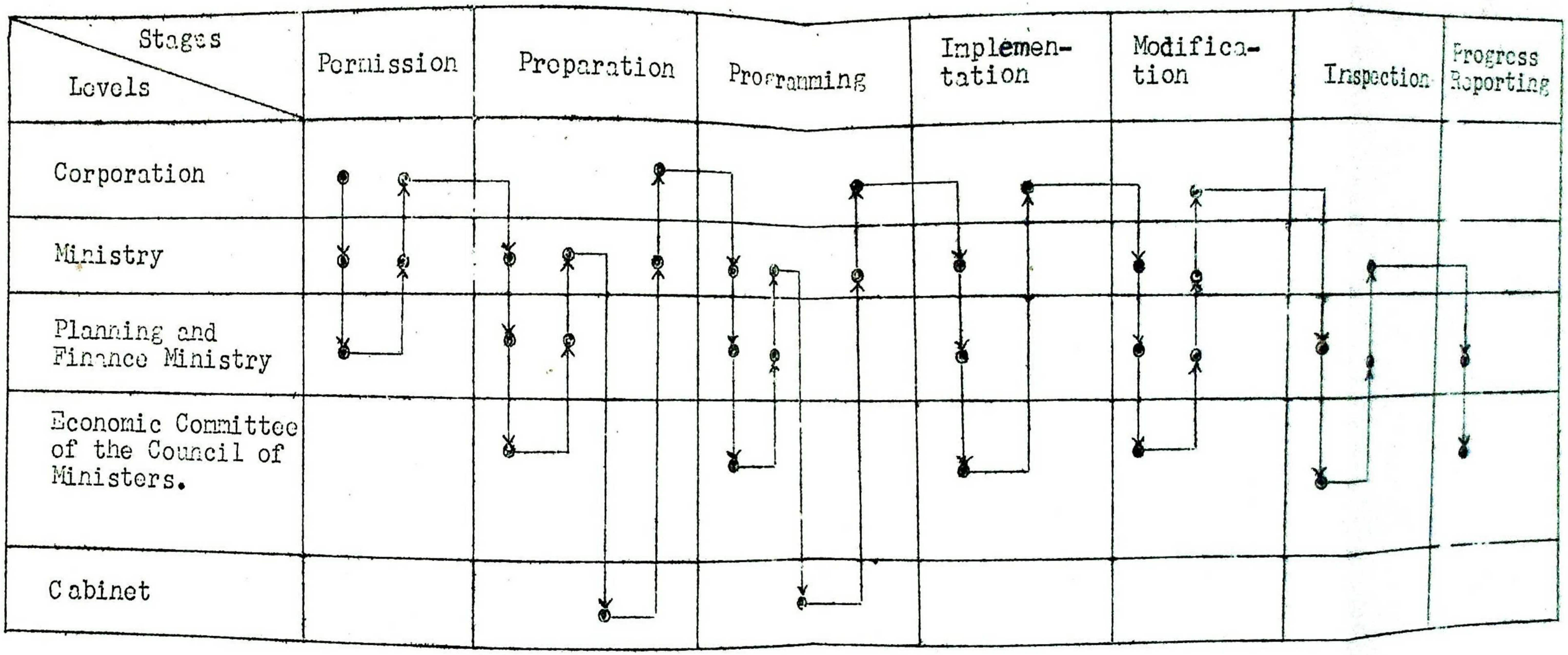

Fig. (14). Process Chart Showing Different Stages of Project Formulation and Implementation.

Source : Adapted from - <u>Stages of Preparing New Projects</u>. Planning and Finance Ministry, Planning Department, Union of Burma, 12 Jan., 1973. (in Burmese).

time of implementing it successfully.

The procedure for the approval of the budget for the corporations and government departments can be stated as follows.

State enterprises, government departments and corporations prepare the required budgets for every financial year, and submit to the Planning and Finance Ministry. The budget department of the Planning and Finance Ministry compiles these budgets and prepares the national budget and pass to the Financial Committee through the Planning and Finance Ministry. When the Financial Committee approves this budget, it is submitted to the cabinet by the Planning and Finance Ministry. When the cabinet approves this budget, it is presented at The Pyithu Hluttaw by the Planning and Finance Ministry, for final approval.[1]

Since the prices are not stable, there have been great price differences from time to time and as the exact rate of inflation is not available for the state enterprises, it is difficult to estimate the required budget. Furthermore, the amount of budget approved is inadequate in most cases.

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1. The Council of state issued a proclamation in August 1976, on the transfer of duties and rights to peoples' Councils at different levels. Thus, the existing budget preparation system will change starting from 1977.

(iii) The Customer or the Demand of the Enterprises.

Generally, the origination of the projects comes from the customer enterprises or clients which are mostly state enterprises. When a project is approved to be launched, the customer enterprise directly approaches the sponsored enterprise or invites tender for the new project or work, both from local and foreign countries. Thus the industries and corporations compete for the work. The customer usually chooses the least bid industry or corporation for the new projects.

Before 1975-76, documental agreements had never been made in dealing with the customer enterprise, except in rare cases, when there were more than one enterprise involving in a project. According to the government policy, it is settled that, in the coming future, all government corporations must run on a commercial and competitive basis. Thus when the customer enterprise approaches the corporations for a new job, contractual agreements must be made with the customer. The agreements include terms of payments for the work, and if the sponsored corporation cannot complete the work within the target date, it must give penalty. The customer enterprise must obtain the required budget for the project to be undertaken, before the payment for the project is settled.

For example, the customers for the Construction Corporation may be the Ministry of Education, the Ministry of Health, the Housing Department and the like. The customers for the Sinmalike Dockyard Corporation may be Five Star Line Corporation, Myama Oil Corporation, Inland Water Transport Corporation, Irrigation Department, State Timber Corporation, etc.

(b) Organizational Factors.

Organizational Factors are concerned with the management of project implementation. Management is responsible for organizing, coordinating and channelling the efforts of the personnel in the most economic and efficient way to execute and monitor projects. Top management and project manager are mainly engaged in the management of projects.

(i) Top Management.

Top management seems to be concerned chiefly with policy measures and have full authority and responsibility for the implementation of projects. Generally to supervise and control, to solve problems impeding project implementation, and to take strategic decisions are the main functions of the top management. There seems to have a trend of centralization in the management of projects.

(ii) Project Manager.

Once a project is decided upon and approved to be launched, a project team is formed with competent personnel charged with the responsibilities to execute the project in accordance with plans, schedules and objectives. A project manager is selected by top management for his technical competency and his experience in managerial and organizational skill and aptitudes.

He is project oriented, and he has to devote full time to the project. The project managers role, basically, is one of planning, controlling and motivating the project team. He has to cope with situations involving people, time, money and technology. He is to coordinate the efforts of all parties engaged in the project and to maintain communication within the project team. Operational decisions which are of day by day nature concerning workers, materials and scheduling are made by the project manager. Project manager is frequently an engineer or a person who has a primary background in the project's main field of activity. He becomes a unifying agent with respect to the total management function.

Generally, the top management and project manager are engaged in project implementation as mentioned above.

As the field study was done in Pyithu Hluttaw building project under Construction Corporation and oil barge construction project in sinmalike Dockyard Corporation, the organizational factors of these projects will be summarized here.[1]

A project team is established for the Pyithu Hluttaw building project. Committees are formed to manage the project implementation, including managing committee, coordination committee, and working committee. There is no such a person appointed as the project manager. But staff officer I and the chief engineer who are executives of the working committee seem to have the rank of the project manager. They are responsible for planning, and field work. The managing committee and the coordination committee are the top management and the work to be undertaken depends upon their decisions. These three committees are responsible for achieving the targets within the time scheduled.

The Sinmalike Dockyard Corporation is merely a business organization and the projects under

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1. The organization set-up of these projects is treated in detail in the next chapter.

taken are the type of the going-concern projects. There are no separate project teams. The whole organization is involved in carrying out the projects. The managing director and the deputy managing director are the top management who are mainly concerned with policy matters, defining the duties of the individuals in the organization, and applying for financial approvals. The general manager seems to have the role of the project manager, and is mostly engaged in detail performance of the organization.

(c) Operational Factors.

Operational factors are those factors which include in the process of implementing the projects. Functional managers are responsible for work assignment and incentives, and provision of materials and supplies during the operating phase of the project. Most of the expenditures, technical performance and work progress depend upon the performance of these factors.

(i) Functional Managers.

Functional managers are assigned to different sections of the project team. They support the project manager according to their instructions in carrying out the project. A project manager must rely heavily on capable managers to handle the details of project operations. The support they give to the project managers is an important factor in meeting project's objectives.

In the Construction Corporatio, when a new project is approved to be launched, a project team is formed with the competent personnel charged with the responsibilities to execute the project in accordance with the plans and schedules. A project manager is selected by top management for his technical competency and his experience in managerial and organizational skill.

The project team for the Pyithu Hluttaw Building project consists of three committees, namely, working committee, coordination committee and the managing committee. Seven sections included in the working committee are Architecture, Design, Estimation, Electrical, Quality Survey and Research, Sanitary and Water Supply and Field Work. Each of the five sections has a staff officer II as an incharge, and the field work section has an assistant command engineer as the incharge.

Staff officer II and assistant command engineer have the role of the functional managers. They are members of the working committee and support the working committee with the required information under the direction and supervision of the staff officer I and chief engineer who are the executives of the Working Committee and who have the rank of the project manager. Operational decisions, which are of day by day nature are made by them. Major decisions are made by the top management.

Thus, the project team of the Construction Corporation is formed systematically. The functions of the team members are specifically defined and are project oriented.

In the Sinmalike Dockyard Corporation, there are four major departments, vis. Engineering, Stores, Accounts and Personnel. Assistant Managers, engineers, accountants and stores officers of the respective departments likely to have the role of the functional managers. They are under the direct supervision of the manager, chief engineer and chief accountant.

When a new project is decided upon and approved to be launched, the general manager chooses suitable individuals from the four departments for the implementation of new projects. The whole organization is a business organization and the projects undertaken are the on going types. The functions of the individuals are not specifically defined and are not project oriented. When a project is approved to be launched, individuals are selected from the four major departments, to implement the new project.

Thus there are no separate project teams like the Construction Corporation.

(ii) Provision of Materials and Supplies.

Once a project is launched, raw materials and supplies are the first to be procured. They are usually bought by tender system from abroad, or ordered from local corporations within the limits of the budget allotment.

The local made raw materials are usually provided by the government corporations such as State Timber Corporation, Peoples' Engineering Industry, Burma Railways Corporation etc. As the information on the quality and type of raw materials manufactured by these corporations are not readily available, it is a time consuming task to inquire them whether they are producing the required material or not. It seems that these corporations do not cooperate in procuring the local made raw materials, and they are not interested in the special orders. The local procurement of raw materials is done by the approval of the top management of the organization.

Foreign materials are procured by the approval of the minister level. Before 1975-76 two methods of foreign procurement system were operated. The first system was that the customer enterprise obtained the foreign exchange required for the raw materials and procured the raw materials which were later transfered to the sponsored corporation. Another method was that the foreign exchange required for the raw materials was obtained by the customer and transfered to the sponsored organization for procurement of raw materials. In 1975-76, the foreign exchange for the raw materials for a certain project is obtained by the sponsored organization,and materials are procured by the tender system,also by the sponsored organization. The foreign exchange which will be required for the raw materials is already estimated in the budget allotment of the sponsored Corporation.

The procedure for the foreign procurement generally takes the following steps.

1. Designs and drawings of the required materials.
2. Specification of materials.
3. Inviting tenders.
4. Vetting and choosing.
5. Foreign exchange estimation for the materials.
6. Obtaining foreign exchange.
7. Sending purchasing order.
8. Opening letter of credit.
9. Custom clearance and port duty.
10. Materials delivered.

When the specification of materials is made according to the designs and drawings of the engineer, tenders are invited and chosen by the vetting committee. The required foreign exchange is then estimated and obtained, and the purchase order is made. If it is accepted by the suppliers, letter of credit is opened at the bank by the purchaser. After the shipments of materials are arrived at the port, custom clearance and port duties are paid and the materials are delivered. The corporations can buy the foreign materials on their own or through the MEIC as an agent.

After the purchase order is made, corporations and departments can transfer the required foreign exchange to the MEIC and the purchasing of foreign materials can also be done through MEIC.

In order to open letter of credit at the bank, the corporations deposit the local currency at the foreign exchange bank, the amount of which is equivalent to the required foreign exchange. This amount is charged from the current accounts of the corporations.

In Sinmalike Dockyard Corporation, general items (for example spare parts) are usually delivered nearly eight months after the tenders are invited. Special items (for example, machines, engines) take nearly one year to be delivered after the purchase order is made. Furthermore, the size of the order being small, naturally do not attract immediate attention by the suppliers, and in cases where the requirements are in a set, incomplete supplies meant unnecessary hold up. Because of the lack of standardization of materials, there is difficulty in specifying the materials to be ordered. The SDC usually manufactures the required local materials from its manufacturing department.

Pyithu Hluttaw building project mostly depends upon local made materials up till now. Most often, the required amount and quality is not available in time, thus delaying the progress of work.

(iii) Work Assignment and Incentives.

During the process of project implementation, individuals involved in the project are assigned with tasks by their supervisors from higher to lower levels. For example, the tasks are assigned from top management to project manager, and then to functional managers and lastly to the personnel and workers. Verbal communication is mostly used in assigning work responsibility. Problems such as, lack of specific machines, obsolescence of machines, lack of skilled workers and qualified staff seem to occur, during the execution of the projects. These problems entail slippages in schedule, over expenditures, and repetition of work.

In Sinmalike Dockyard Corporation, workers in lower wage groups look for outside money without having interest in their work, because of general price hikes. This has adverse effect on their performances. In 1973, the management did try a method of material incentive based on actual mandays, by providing sleeping accomodation, while they are asked to work 12 O' clock in the night. This arrangement was made at the hull assembly of the coastal oil tanker construction project, for a duration of three months. That experiment had a positive effect on the willingness of the workers and the time taken for hull assembly was tremendously shortened. The workers and supervisors also received extra allowances. But prompt payment was not possible, as the financial approval took a considerable period of time. The management realized that this type of arrangement was only good for job and piece work and for a short period of time.

Another method, which is based on the weight of the completed work has been introduced very recently in 1975, at the oil barge construction project. This system has two phases. In the first phase, total bonus is calculated for the volume of weights over the standard weight (80 lbs/man-day). At this stage, bonus cannot be calculated for each individual worker due to lack of time study staff. In the second phase, the total bonus for the whole work is divided according to the ratios of individual working days or working hours. This system does not equally affect the workers at different trades.[1] However, the results seem to be so far satisfactory and the management is trying to improve this method. Thus the incentive system in Sinmalike Dockyard is progressing.

In Pyithu Hluttaw building project, piece rate system is frequently introduced, so as to speed the rate of workers and to shorten the duration of work. Inadequate machines and equipments, lack of skilled workers, seem to be the main difficulties in the implementation phase of this project. As the higher authority takes time to make decisions, the staff who are to carry out these decisions are most often idle.

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1. The hull assembly work involves greater amount of weight for even an activity, where the outfitting work involves small amount of weight for a number of activities. Thus the bonus of outfitting worker will be lower than the hull assembly worker according to this system.

Under these existing situations of the industrial environment, CPM/PERT is applied only as research study, probing into its feasibility and application in Burmese industries.

4.2 Research Procedure of CPM/PERT Application with Respect to the Case Studies.

Lathe machine manufacturing and oil barge construction are the two projects, where the trial application of CPM/PERT was undertaken with respect to time analysis at the Sinmalike Dockyard Corporation. The procedure of the application was carried out by a series of clearly defined steps, which can be stated as follows :

1. Job and time analysis.
2. Preparing the activity list and rough network.
3. Modifying the network.
4. Finalyzing the network.
5. Coding the input data.
6. Punching.
7. Computer application.
8. Correcting errors.
9. Obtaining computer reports.
10. Analysing computer reports to see if it is necessary to refine or revise the logic or time estimates.

11. Updating and replanning the network.

These steps can be illustrated by a flow chart, see Fig. (15). For further explanation, this flow chart can be generally divided into three phases, which are :

(a) Project planning phase.

(b) Computer application phase.

(c) Project control phase.

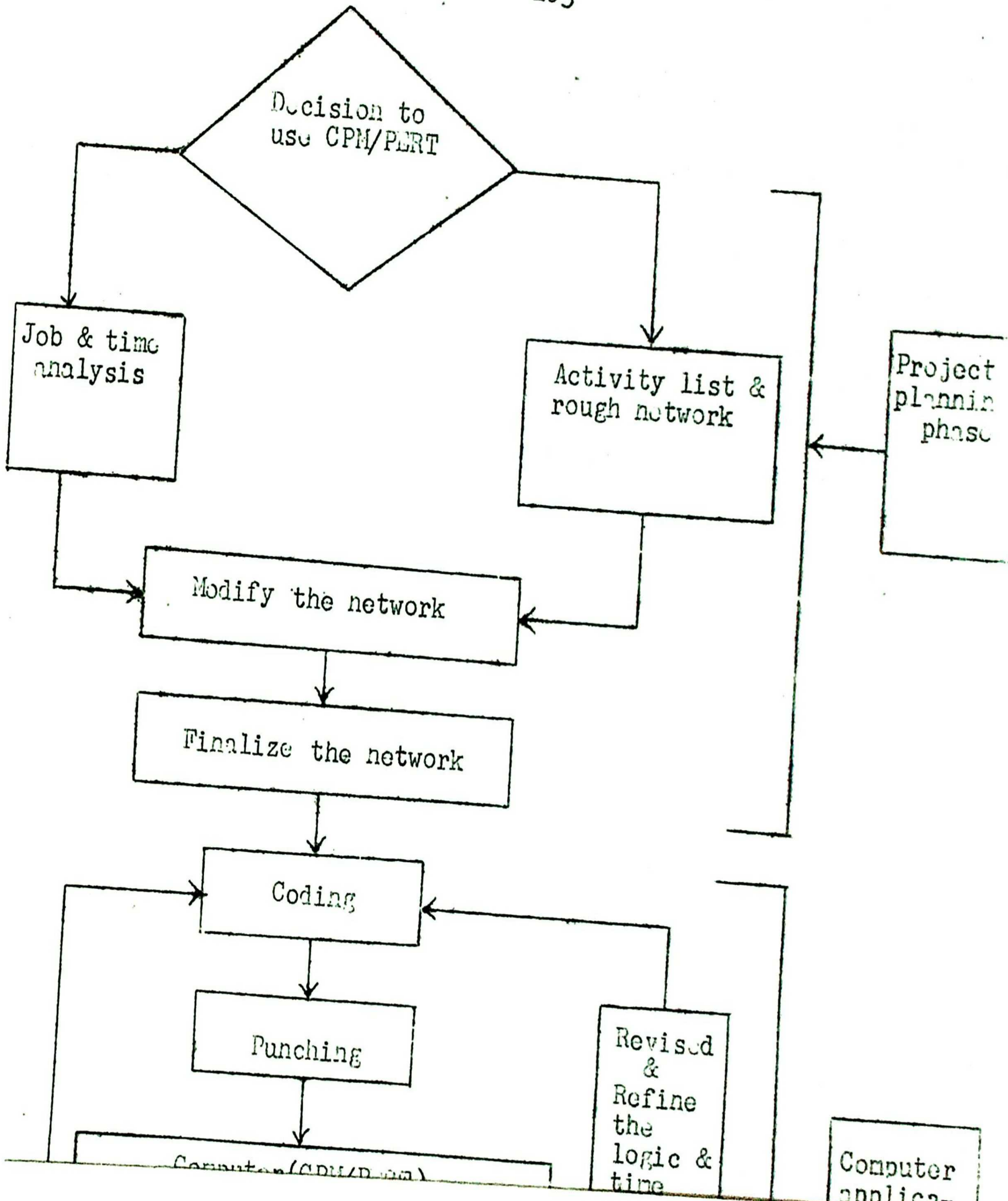
The decision to apply CPM/PERT is only on the experimental basis, just to find out whether it is worthwhile for further application.

(a) <u>Project Planning Phase</u>.

Initial development of the schedule is described as the planning phase, which includes job and time analysis, preparing activity list and drawing the network. It is a basic necessity to get a thorough understanding of the work where the CPM/PERT is to be applied.

Work and time analysis of the operations included in the projects were made with the cooperation of the persons who were responsible for carrying out the projects and who sufficiently understood the operations.

When the basic idea of the operations included in the project was developed, the list of activities


Decision to use CPM/PERT
Job & time analysis
Activity list & rough network
Project planning phase
Modify the network
Finalize the network
Coding
Punching
Revised & Refine the logic & time
Computer applica-

which constitute the projects were obtained. Before the network could be drawn, the correct sequence or logic of the operations was decided upon by consulting the individuals of the projects. The next step was the preparation of the network according to the established rules. As the final network could not be achieved at the first attempt, a draft network was first prepared. After redrawing it repeatedly, the modified network was obtained. By consulting with the individuals of the project whenever difficulties arose in the drafting process, the final network was obtained, after expressing and clarifying some points in the modified network. Thus the preparation of the network was a frustrating process.

One difficulty lies in deciding what degree of detail in the network is required for control. A complex network whilst being a source of pride to the person who constructs it, is likely to fail in its capacity as a communication document. On the other hand, networks with excessive details can overwhelm users and tend to get ignored. For these reasons, much detail on the network for the projects was avoided. By considering the needs of the individuals who might use them, the number of activities were reduced to a certain amount which might be meaningful to them.

Once the arrow diagram was completed, the events of the network were numbered, and the three time estimates for each activity in the network were made with allowances for the delays which can be encountered during the implementation of the projects. The project planning phase was completed at this stage. The planning phase of the case studies undertaken at the S.D.C. took nearly six months.

(b) Computer Application Phase.

In applying CPM/PERT, the required analysis of the networks was made by using the computer at the Universities Computer Center.

The computer application phase in this paper includes, coding, punching, and correcting processes to determine the start and completion date for each activity in the network, the critical paths, expected time for each activity and the floats. Before the input data for the computer are prepared, it is necessary to get acquainted with the coding process and the computer reports.

By using the activity lists and time estimates, the required input data for processing were coded on the coding sheets by consulting with the computer personnel, and by studying the PERT manual. Coding is a tedious and time consuming job, which requires taking of pains in recording and checking. The coding sheets were then punched on the cards and submitted to the computer.

The initial results of the computer may contain errors in coding and punching. These errors have to be corrected, coded and submitted to the computer to get the correct results.

Since it was the first attempt to make use of the computer, with its PERT program, there were many errors in the initials results for the projects of the S.D.C. Because of these errors, there were many rerun operations before the correct results were obtained. Although the results from the computer were obtained within seconds, correcting the errors and punching the input data caused the delays.

(c) Project Control Phase.

This phase includes making major changes in the schedule as the project progresses, revising the network accordingly and computing new schedules.

When the correct results for the oil barge construction were obtained, it was found that the results were not competible with the actual situation, due to the mistakes in time estimates and errors in the logic of activity relationship. Thus the time estimates were revised and the sequence of activities were rearranged. The necessary networks were redrawn and the input data for the computer were coded for the new plans and submitted to the computer. By this time, the computer reports revealed the actual situation and were acceptable by management for supervising the work.

Hence, it can be pointed out that the application of CPM/PERT in the projects of S.D.C. as an experiment is successful. Up to this stage, it is merely the process of developing the fundamentals of the technique, and introducing it as a trial application until it is acceptable by management.

As the construction of the oil barges progressed, replanning process was carried out, to demonstrate how the project can be controlled.

By analysing the critical path, total floats and the earliest dates of the critical activities, the sequence of some of these activities were changed to get a smooth sequence. The new network plan was redrawn and the input data were prepared and submitted to the computer. The results of the computer indicated that the duration of the new plan was more shorter than the previous plan and was more acceptable.

As a new labour group was available for the oil barge construction project, it was assigned to the activities on the new critical path of the new plan. Thus the sequence of the critical activities were rearranged and a new network was prepared again. Computer reports were also prepared for this plan.

By this time, the results showed that the duration of the project was the least of all the previous plans. According to this plan, the difficulties and problems which can be encountered during the operation can also be anticipated with due allowance.

By CPM/PERT, the management of S.D.C. is able to estimate the duration of the project and can control the progress of work against the schedule. Management can also analyse the effect of delays and can introduce alternative methods or put more labour resources to overcome the delays. Management is also able to change the plan immediately when the existing situation demands.

By realizing these salient points and how the original plan can be improved to get better results, the management of S.D.C. is getting more interested in the application of CPM/PERT in project management, and considering to make use of the technique in supervising and controlling the oil barge construction project.

CHAPTER 5

Experimental Application of CPM/PERT Technique.

Shipbuilding projects of the Sinmalike Dockyard Corporation and Pyithu Hluttaw building project of the Construction Corporation were chosen for the trial of the CPM/PERT in project management, to see how far it would be feasible and useful for management in controlling the work. Therefore, the nature of the study was more of an experiment to find out if CPM/PERT application was worthwhile for installation.

5.1 Pyithu Hluttaw Building Project.

CPM/PERT being developed for the management of complex projects, would be ideal in planning, scheduling, and controlling the Pyithu Hluttaw building project which consisted of a complex of buildings.

Obviously, the successful operation of this technique will acclerate the dynamic implementation of the project, enabling the management to supervise and control it effectively.

Although there were willingness and enthusiasm to try out this technique, the situation for such an experiment was not so favourable at the time of the study.

It was impossible to select the construction work of one building from the whole complex, for the trial of CPM/PERT, because the organization was not in a position for such a trial, as there were too many project operations to be completed within the set time limits. Being a priority project, the engineers who were familiar with the CPM/PERT technique could not spare enough time to discuss about the possible application of the technique and to cooperate in providing the required information. Other staff less acquainted with the construction operation and lacking the knowledge of CPM/PERT would not be the reliable source of information either. Hence, the trial application in this case was abandoned for the lack of time.

However, it will be worthwhile to study the organization set up of this project, to assist in general comprehension in implementation of the projects in the Burmese industrial environment. Thus the study of the Pyithu Hluttaw building project is to help finding out the ways and means of executing a project.

(a) <u>The Project Organization</u>.

A project team has been formed for the construction of Pyithu Hluttaw building project. As the organization chart is still being prepared at the time of the study, the arrangement of the project team can only be roughly stated as in Figure (16).

The "customer" for the Pyithu Hluttaw building project is the Council of State. The required budget for the project for each financial year is estimated by the project team for the Council of State, which later applies for budget sanction and transfers to the Construction Corporation when it is approved. The total budget required for the project is estimated to be about 1332 lakhs of kyats.

There exist three committees in this project. They are, working committee, coordination committee and the managing committee. Minister, deputy minister, Managing director and directors (director of planning dept., and director of work dept.) of the Construction Corporation are the executive committee members of the managing committee; managing director, directors, chief engineer and staff officer I are the executive committee members of the coordination committee; chief engineer of the Rangoon command and staff officer I are the E.C. members of the working committee. See Fig. (16).

Seven sections included in the working committee are Architecture, Design, Estimation, Electrical, Quality Survey and Research, Sanitary and water supply and

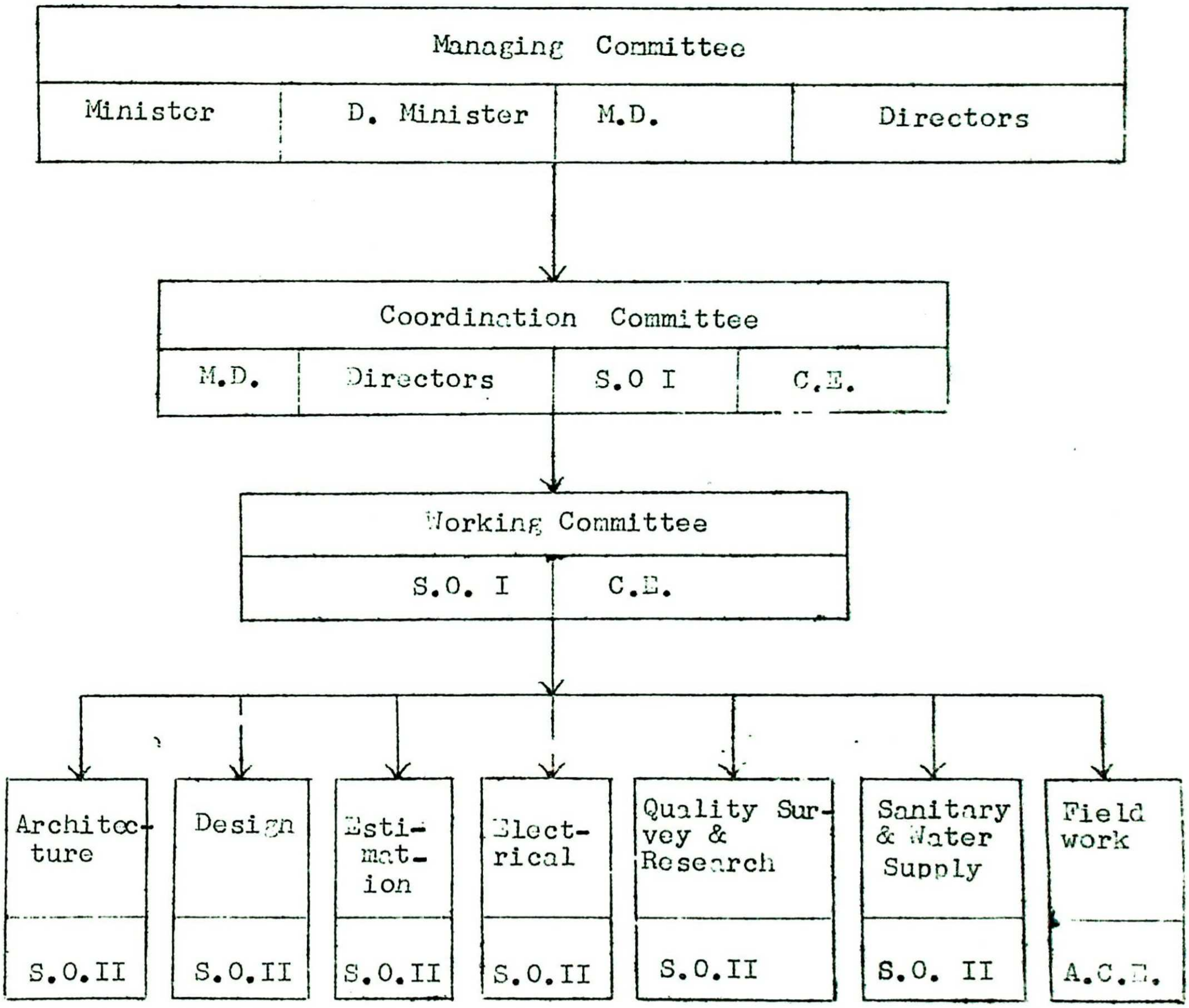


Fig. (16). Set up of the Pyithu Hluttaw building project team.

Field work. Each of the six sections has a staff officer II as an incharge and an assistant command engineer is the incharge of the Field work section. There are altogether six staff officer I in the Working Committee.

Chief engineer and staff officer I seem to have the rank of the project manager. Chief engineer is responsible for the field work, and staff officer I are responsible for planning. They both assign the work load to the seven sections included in the working committee. The individuals in the working committee devote full time to the project. There are about 200 individuals in the seven sections excluding the field workers, who are employed on daily wages or salary basis.

Working committee holds meetings every Tuesday, coordination committee every Friday, and managing committee every Wednesday, to solve problems, to discuss work progress and to take necessary decisions. Thus meetings are hold regularly as the work progresses. Managing Committee is the top management of the project and major decisions are made by this committee. Problems which cannot be solved by the working committee are submitted to the coordination committee. If this committee cannot tackle the problems, they are again presented to the managing committee which makes the final decision.

Staff officer I and chief engineer are responsible for the seven sections of the working committee with respect to when and what of the project activities. The staff officer II and assistant command engineer are in turn responsible to staff officers I and chief engineer for the adequate support of the project.

The working committee uses many innovative graphs and bar charts to report the work progress. Reports are established on a regular recurring basis. The drawings for the structure of the building are prepared by the Architecture and Design sections. As the duration of the project is rather long, the buildings to be completed within each financial year are first decided, and the drawings and designs are prepared for these buildings. The activities to be included in the construction of the buildings and time estimates for these activities are provided by the Estimate section. Based on these time estimates and activities, bar-charts and graphs are developed for each financial year. Labour requirement is also estimated for the volume of work included in the bar charts. As there is no specific standard or norm for the labour, estimates for work schedules are based upon the judgement of the field engineer.

The activities included in the bar charts and graphs seem rather sketchy for controlling, and hence they could be inadequate for comparisons between actual and estimated performances. The preparation of work schedules for each work activity is usually of repetitive nature, according to the frequent changes of decisions taken by top management. When schedules change frequently, the validity of schedules as an element of control is weakened. Once the schedules are drawn they are not usually updated as the work progresses.

5.2 Experiments at the Sinnalike Dockyard Corporation.

The Sinnalike Dockyard Corporation is a business organization and the projects undertaken are the on-going types. The corporation is involved in construction, repairs and maintenance of ships, and manufacturing of spare parts, tools and equipments. The organization chart is prepared in detail, see Figure (17)a and (17) b in the appendix. Figure (18) is a simplified version of the organizational arrangement of the S.D.C.

The Dockyard has 4 major departments, vis. Engineering Stores, Accounts and Personnel. As at November 1974, the Engineering department has 693 persons and the remaining three consisted of 249 persons.

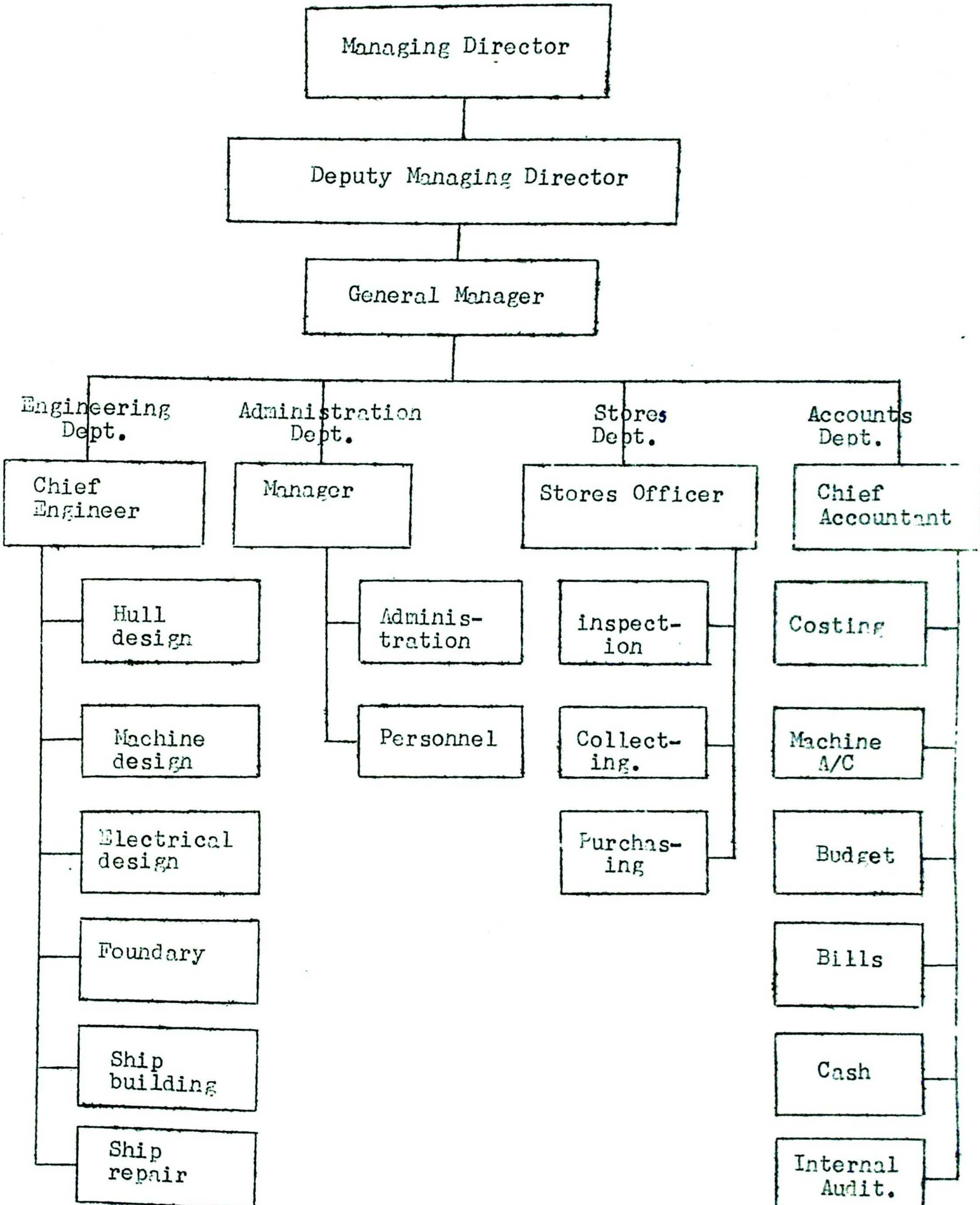


Fig. (18). The organization set-up of the Sinnalike Dockyard Corporation.

The future set-up envisaged is a total of 1303 persons in Engineering and 664 in the remaining three departments. The invested capital of the corporation is approximately 600lakhs of kyats.

Managing director and deputy managing director, are mostly concerned with policy matters and making major strategic decisions. The general manager is mostly engaged in detail performances of the corporation. The procedure for the implementation of new projects in the Dockyard is as follows.

When the customer enterprise approaches the organization with a new job, the top management decides whether it is technically feasible or not. When a new project is approved to be launched, the general manager plans, controls and coordinates the activities involved in the development of the project, supported by four major departments. No contractual agreements have been made with the customer until 1975. Only informal communication was made between the customer enterprise and the corporation. As the corporation is starting to run on a commercial basis in 1975, documental agreements have been made with the customers since then. The agreements usually included terms of payment on the part of the customer enterprise and the penalty clause on the part of the S.D.C. if due date is not met.

When a new project is decided to be executed, the designs and drawings are prepared by engineering department. The activities to be included in the project are fixed and the time duration of these activities are estimated by the design engineer, to prepare bar charts for the work to be done. Because of the lack of adequate planning staff and uncertainties involved in the provision of materials, the initial schedules are developed without further updating and detail scheduling. Thus projects are executed without systematic planning and scheduling and problems are recognized only when they occur. However, coordination meetings of the individuals taking part in the project implementation are held frequently, to discuss the progress of work, and to take corrective actions. For such a corporation like S.D.C. market research should be undertaken, in order to forecast the prospect of the corporation for the coming future. Up till now, the corporation has not yet carried out any market research, and it is difficult to estimate the potential customers.

Managing director has specifically defined the responsibilities of the individuals of the corporation. But it seems that some personnel and staff have to perform the duties which are not according to those specifically defined. Although specific positions required for the organization are defined in the organization chart, many important posts have not been fulfilled yet.

The main study of CPM/PERT application was done at the S.D.C., under such conditions mentioned above. Lathe machine assembly project and oil barge construction project were tried out with CPM/PERT with the services of the Universities Computer Center.

(a) Application of CPM/PERT in the Lathe Machine Assembly.

The plan to manufacture lathe machines in mass production was started in 1974. As the prototype was not developed before, the lathe manufacturing was still on the experimental stage. Thus, the need to monitor and control this project was not so urgent in such a situation. However, lathe manufacturing was tried out with CPM/PERT, so as to get a basic idea of how the technique would assist management in developing a manufacturing and assembly sequence and later in general scheduling.

By using the network plan developed by CPM/PERT technique, the management fixed the sequence of operations included in the lathe manufacturing and study to improve the plan with better alternatives, to meet the time objectives. By doing so, the basis for planning and controlling the manufacturing process could be ascertained, once the Dockyard launches the mass production of lathe machines.

(i) Preparation and Work Analysis.

All projects consist of separate, but interrelated operations. In CPM/PERT these are called activities. The first stage in applying the technique is to obtain a list of all activities, which constitute the project to be scheduled.

Regular visits to the SDC. were made starting from January 1975, to study lathe manufacturing. After the specific parts included in the lathe machines have been produced, the assembly of lathes was carried out. Lathe machine manuals, designs and drawings of the parts included were intensively studied. Discussions with the workers and engineers were made during regular visits to the machine shop.

As there were 662 parts included in the lathe assembly as a whole, it was a problem to fix the degree of detail that should be included in the network. After considering the size, complexity and duration of the project, and the needs of the individuals who might use the network results, it was decided that the lathe machine shall be divided into seven categories and subdivided into 58 bigger units.

After a successive reviewing process, a list of activities numbering 58 came out as the final list of activities required for the lathe machine assembly, see figure (19)[1].

(ii) Planning and Scheduling.

After the activity list was obtained, it was quite a difficult task to fix the sequence of these activities. A group consisting of seven workers was to carry out the lathe assembly. A single shift was available, working eight hours a day. Based on this resource group, the lathe assembly was divided into seven categories as follows (see Fig(2) - Fig.(27) in the appendix.)

1. Cabinet assembly
2. Bed
3. Tailstock
4. Headstock
5. Saddle and slide
6. Apron
7. Gear box (2 types)

Each worker was assigned to each of these category, and the sequence of activities was fixed according to these categories. By dividing into such categories, the network plan would be a technically accurate representation of the plan to be followed. A draft network plan

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1. See appendix.

was developed from the list of activities and their sequence, in accordance with the rules mentioned earlier in chapter 3. By making necessary changes again and again, the final network for the lathe assembly was prepared with 58 activities, see Fig. (28) in the appendix.

Events were coded with combination of letters and numbers with respect to the seven categories. For example, C01, C02, C03.... for cabinet assembly, B01, B02, B03... for bed assembly, A01, A02, A03... for apron, H01, H02, H03... for head stock, G01, G02, G03... for gear box etc. The start event is labled 000X and the end event 9999.

The next job was to put time estimates for each activity. As the workers involved in the lathe assembly were merely apprentices, they could not estimate the time duration for each activity by viewing the network or the activity list. Thus, the personal observation method was adopted, to discuss with them and to observe their operations during their working hours.

Most of the parts produced or molded for the lathe machines are not accurate, making it necessary for further remake operations, such as machining, shaping and grinding. As the workers are not skilled enough, these remake operations are quite considerable and time consuming.

On the other hand, the machine shop of the Dockyard, where the machining operations are carried out, has to provide services not only for lathe machine assembly but also for repair, maintenance and shipbuilding works. Thus, the machine shop is over loaded, and a considerable time elapses to remake the parts required for lathe machines.

The three time estimates (in minutes) were made (optimistic, most likely and pessimistic) to include allowances in such a situation.

(iii) Computer Application.

The program for CPM/PERT is already available in the computer of the Universities Computer Center. It is the ICL 1900 series PERT Package. The 1900 series program has special program facilities for dealing with the complexities of interrelationships and sequencing problem. The 1900 series PERT Package is a comprehensive set of linked computer programs to provide project planning and control by means of time analysis, resource analysis and cost analysis.

However, only time analysis was made for the lathe assembly, as it was the first project to be tested with the CPM/PERT in this study.[1]

Time Analysis program allows management to plan projects on a time basis and to ensure that sound work schedules are prepared. The Time Analysis program calculates the earliest and latest start and finish dates for all activities in the network. The printed out may take one of two forms: it may consist of lists of activities or events in various sequences, such as by earliest or latest start or finish sequence or by total float sequence, or it may be bar charts of activities. Both format may be used to highlight critical path activities. If the schedules produced are unacceptable, the network may be revised and re-analysed until statisfactory results are obtained. The sequence of items to be printed may be varied by the user. The purpose of Time Analysis program is to reduce multiple time estimates to an expected time and to use these estimates of activity durations as specified by the user in calculating the following:

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1. Dr. Kin Maung Kywe tested the CPM/PERT pakages during 1973 and 1974, in outfitting operations of "Hluttaw", the first coastal oil tanker ever built by the SDC. See "Application of Computer and PERT Technique in Management Control of Industrial Projects (An Experiment at the Sinmalike Dockyard)," mimeographed material, Department of Commerce, Institute of Economics, 1974.

1. The earliest and latest dates at which the events may be achieved.
2. The earliest and latest start and finish dates for activities.
3. The amount of total floats on activities and slack on events.
4. The critical path through the network.

After the PERT Manual was thoroughly studied, the coding sheets were prepared for lathe assembly, see Fig. (29).[1] They were coded in such a way to get the desired results. The coding sheets were then key punched and submitted to the computer. The results for lathe machine did not come out easily. Mistakes in coding and key punching and correcting the errors caused considerable delays.

The final computer reports form the basis for improving the lathe assembly method, when the mass production of lathes is carried out. Management can control the lathe assembly work and make timely corrections for difficulties encountered. Adjustments can also be made with the activities which are critical to on-time project completion. By analysing the computer reports, Management can determine valid means of shortening the time along the critical path, by applying new resources or additional

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1. See appendix.

funds. which are obtained from those activities that can efford it, because of their float condition.

(b) Application of CPM/PERT in Oil Barge Construction Project.

S.D.C. has made contractual agreements with the Petrochemical Industrial Corporation since December 1975, for the construction of twelve 500-ton oil barges. It was agreed that the Dockyard Corporation must produce and deliver twelve oil barges within one year, and if the delivery date is later than the agreed date, the corporation must pay penalty. Thus, it is the first project to be launched in S.D.C. after the adoption of commercialization policy in state enterprises in 1975.

It is obvious that whether the corporation can deliver the oil barges on the required date or not, is the determining factor of the profit or loss of the corporation. If each oil barge can only be completed earlier than the expected date, their float time can be used fruitfully in the construction of the next oil barges. Thus, the need to monitor and control this project is so urgent in such a situation. As the CPM/PERT experiment in the S.D.C. is based on the construction of five oil barges, it has become useful for the management after completing the fifth oil barge, as the computer reports serve a good basis for replanning and rescheduling.

The process of CPM/PERT application in oil barge construction project with respect to time analysis is more complete than the lathe assembly project, because it considered all the steps that should be included in this process, which is mentioned and explained earlier by a flow chart.

(i) Preparation and Work Analysis.

Oil barge construction is divided into two parts; hull assembly and outfitting work. The oil barge consisted of six blocks or sections; forepeak section or block 1, aftpeak section or block 6, and blocks 2, 3, 4, 5. Each part is built separately and are later assembled together. In other words, the Dockyard follows the modular method in oil barge construction; see Fig. (30) - Fig. (33) in the appendix.

Regular visits were made to shipbuilding department where the oil barges were constructed. As the sequence of jobs included in the oil barge construction was so complex, it was difficult to combine hull assembly and outfitting works in a single network. Thus, seperate network diagrams were prepared for hull assembly and outfitting work.

The multitude of work in preparing the list of jobs and the work sequence of each detail of the task involved in hull assembly and outfitting was discouraging. After an intensive study and serious discussions with the engineers, the list of jobs included in the hull assembly and outfitting work were prepared as in Fig. (19) with 167.activities and (67) activities respectively.

It was a hard task to fix the sequence of these activities. However, by reviewing the dependent activities and independent activities repeatedly, the sequence of activities was finally established. The responsible personnel for the oil barge construction were asked to review the activity list and their sequence, in order to confirm that the activities included in the hull assembly and outfitting work were accurately and realistically covered.

(ii) Planning and Scheduling.

Eight groups of workers, consisting four platers and three welders in each group, were assigned to carry out hull assembly; whereas two work groups with six workers in each group, were available for outfitting work. There were two shifts of workers working sixteen hours a day for both work.

The creation of the network is a fairly demanding task, as it has to indicate the number, kind and sequence of activities needed to execute the project. To simplify the process of drawing the network, the entire hull assembly was subdivided into nine groups namely, side plate, deck plate, floor unit, blocks 1,2,3,4,5 and 6, depending upon the available work groups. The draft network for the hull assembly was drawn with 167 activities. After drawing a series of successive drafts, the final network for hull assembly was developed see Figure (34),Plan 1.[1] Thus the construction of network was a tedious and time consuming job.

In coding the events, the letters corresponding to the above nine categories were combined with numbers, as it was done in the lathe assembly. The six blocks were numbered one to six. For example, B1 for block one, B2 for block two, B3 for block three and the like. For deck plate, it was labled DK, for side plate SP and for floor unit FR etc. Thus, the events were numbered according to the type of work to be performed.

The network for outfitting work was prepared with 67 activities. To get a clear presentation of the network, activities involved in fixing anchoring equipment were divided into two groups namely anchoring equipment group I and group II. Activities included in fitting

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1. See appendix.

and fabricating pipes and valves were formed into S.V. group, i.e. ship's valve group. Activities for fabrication of bollards, towing bit, and pushing block were named M.group.[1] After improvements were made in the draft network, the final one for the out fitting work was obtained, see Fig. (35).[2] In numbering the events, the letter F was fixed infront of the numbers such as F01, F02, F03... to indicate outfitting work.

Outfitting work is required to be carried out during the hull assembly of six blocks, and also after the assembly work is completed. If the details of hull assembly of six blocks are to be included in the network for outfitting work, the network will not be clear and concise. Thus, only the main assembly work of the blocks, where the outfitting work can be carried out before and after the assembly work, was included in the network for outfitting.

As the network for the outfitting work includes the general overall work of the oil barge, it can be labled master network, whereas the network for the hull assembly can be labeled subnetwork, since it only shows every detail of hull assembly work for the six blocks.

After the network configurations were developed for the oil barge construction, the next job was

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1. Mooring equipments.
2. See appendix.

to put three time estimates for each activity. Hull assembly could be delayed, because of breakdowns of machines, such as crane, shear machine, folding machine and hydraulic press. Hull assembly needs skilled welders, as there are considerable amount of welding op- operations included in hull assembly. A welding operation needs a vast experience. When the welder comes to a complicated part of the ship, he has to know how to weld in a difficult situation, as well as the sequence with which the welding must be carried out. If the welder is not skilled enough, remake operations will be many. Foundry and manufacturing department are responsible for the fabrication of parts for the hull assembly and outfitting work. The finished part is tested and remade, if necessary, until it is accepted as satisfactory.

Under these conditions, estimation of time (in hours) for each activity tended to/be arbitrary, although it was made with due care to include possible allowances. However, the time estimates had come close to reality after completing the work for five oil barges.

(iii) Analysis by Computer.

Time analysis was made for the hull assembly and outfitting work. The input data was coded on the coding sheets as in Fig. (29) and then transfered to punched cards and submitted to the computer as in the case of lathe assembly described above.

The available shifts of workers, total working hours a day, and the required sequence of reports were included in preparing the input data for hull assembly and outfitting work.

As the number of activities were considerable, the hull assembly had to run seven times, and the outfitting work had to run five times on the computer, before it come up with the correct computer print-outs or reports.

Five types of computer reports are made available.[1] The computer reports show the calculated average time for each activity. The completion time for each activity is given in calendar dates.

When the network has been constructed and the results assembled in such convenient manner, the plan can be examined in its entirety. There are two main questions to answer. Is the plan a satisfactory way of carrying out the project ? Is it the best plan?

The first computer reports showed that, the duration of the master network was 21 days[2] while the

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1. Explanation of computer reports are given in the appendix.
2. The duration of the Network plans (in days) are computed from the calendar dates of the computer reports. These durations exclude sundays.

duration of the subnetwork was only 58 days, which was illogical. As the master network included the overall operations of the oil barge construction, its duration should be longer than that of the sub-network, which included only the detail of hull assembly.

Upon reexamination, it was found that, the time estimates of the hull assembly were nearly 60% more than they should be. It was also found out that the network for outfitting work left out some activities of hull assembly which should be included in it. Thus, the results of the first attempt of the CPM/PERT application were rejected, as theywere far from reality.

The time estimates for the hull assembly were revised, and the master network was redrawn, see Fig. (35). The input data for the revised schedules were prepared and submitted to the computer again.

The second computer reports indicated that, the durations of the master network would be (29) days and that of the sub-network would be (28) days, which were quite realistic. Further adjustments can be made within the context of the performance of the workers and working conditions. However, the corporation will be able to produce twelve oil barges within a year, according to this network plan.

(iv) Replanning the Oil Barge Construction Work.

As the project progresses, it is necessary to make changes in the logic, as the demands of the situation varies. Thus the project network should be replanned accordingly, to render it valid as an effective control tool for management.

In general terms, it is necessary for the corporation to construct the oil barges at the rate of one every month. If the hull assembly time can be reduced, the probability of meeting the target date will be increased. According to the computer reports, the cirtical path of the subnetwork showed that the critical activities were those of the assembly of the six hull blocks, see Fig. (34), Plan I. As the critical path controls the entire work, the attempt to reduce the time through this path can correspondingly reduce the duration of the hull assembly.

After a check was made further down the computer reports where the total floats were computed, to ascertain whether the activities included in the change have enough total floats, the sequence of some of the critical activities were changed and the sub-network was redrawn, see Fig. (36), Plan 2 in the appendix.

The input data for this new plan was reprepared and submitted to the computer. By this time, the third computer reports indicated that the total duration of the sub-network would be (23) days and the new critical path moved to the assembly of deck plate and beam and girder operation, see Fig. (36).

Up to this stage, the hull assembly would take (23) days and the outfitting would take (29) days. According to this plan, it is quite certain that the corporation will be able to meet the target date of delivery in time. However, provision of allowances for the unpredictable risks was absent in this situation.

One way of reducing the critical path is by assigning more workers to the critical activities. As new labour groups for outfitting work and hull assembly were available, the master network and sub-work were reprepared, by assigning the new labour groups to the critical activities.

The critical path of the sub-network, being the assembly of deck plate and beam and girder operations, these two operations were separated, and a new labour group was assigned to each operation with the network redrawn, see Fig. (37), plan 3 in the appendix.

As for the outfitting work, the critical path being the assembly of hull blocks, see Fig. (35), it was separated into two parallel operations (assembly of blocks 4 and 2; assembly of blocks 5 and 3), and a new labour group was introduced to each operation, and the master network was reprepared; see Fig. (38).[1]

The input data for the new plans were prepared and submitted to the computer. The fourth computer reports indicated that, the duration of hull assembly would be (19) days and for the outfitting work would take (22) days. By this time the results were more satisfactory from the point of view of management. The degree of certainty is increased in fulfilling the customer's order within the target date, even if the corporation encounters some disturbances during the implementation process.

By using these network plans and computer reports, management can detect the inevitable divergence from the targets in advance and can take corrective adjustments. It can also easily improve these network plans if new alternatives are available depending upon the demand of the customer enterprise. It pinpoints attention to the small subset of operations that are critical to project completion time, thus contributing to more accurate planning and more precise control.

The network chart is an excellent tool for communicating scope, as well as details of the operation to other persons directly and indirectly concerned. The completion of each scheduled activity provides a

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1. See appendix.

measurement point and a concrete stage for assessment of progress. A delay of any one activity can be assessed for its effect on the overall project duration, and steps can be taken to adjust personnel assignments, or to work around the delay, if the activity is critical to on-time project complbion.

(c) Human problems of CPM/PERT Application.

One of the problems associated with CPM/PERT application is due not to the inadequacy of the technique itself, but rather to the failure of management to accept is application. For many reasons, related to human relations, top management has not been eager in persuading both operational managers and technical personnel to use CPM/PERT.

The top management fears that the cost of implementing CPM/PERT, including its impact on the operating organization may be too high for the organization to afford it. Having no experience in using the technique as in the case of the Sinmalike Dockyard Corporation, the top management is prepared only for the research stage. The implication is that, the top management itself needs to understand the technique and its work dimensions, leave along the widespread application within the organization.

The resistance to change stems from fear of the unknown or from dread of the uncertainties. Fears thrive on lack of knowldge and are generated when men anticipate unknown changes that may affect them adversely. Because of the detailed planning demanded by the CPM/PERT technique, those operating personnel, who are not familiar with the technique fear that the top management may use it for tight controls. Hence, they are unwilling to provide higher management with a detailed plan or even to carry out any detailed planning at all. The fear that they would never be able to master it, is one of the greatest obstacles in an effort to try the technique.

The operating managers on the other hand may be well equipped with the theoretical knowledge of the CPM/PERT technique as found in the case of the Sinmalike Dockyard Corporation. From their viewpoint, the situation is a complex and frustrating one. The desire to sell the idea of the technical application to top management is as much strong as the doubt to convince themselves if the workers would be willing and able to comply with the technique in the given situation.

If CPM/PERT is to be applied as a control tool, there must be a disciplined work force. Any attempt to introduce discipline is liable to be resisted by the workers.

Thus the operating manager must confront the problem of making the workers understand to accept a new technique. Moreover, it would need to devise a more systematic production control system which requires a general involvement of the personnel of all levels within the organization. It might amount to the whole-sale change in work procedure in the S.D.C.

The attitude of the people working on the project are more important than the management control and tools. Due to lack of work discipline and duty consciousness, operating personnel usually have a sense of acquiring welfare and wage rather than taking pride in achievement and skill through their experience.

Under these circumstances it might be said that CPM/PERT could be applicable only at the project manager level. Project managers may be well acquainted with these techniques and the benefits obtained by them. But the actual application of the technique as indicated above would need a tremendous work in dealing with human problems of the organization.

CHAPTER 6

Conclusion

CPM/PERT provides means of determining which jobs or activities of the project are critical in their effect on total project time and how best to schedule all jobs in the project in order to meet target date at minimum cost.[1] Computationally CPM/PERT is a very efficient method for calculating optimum solution. Since its advent in the late 1950's, CPM/PERT has materially alleviated the communication barrier between different skills, different levels of management and different organizations.[2] Furthermore, they have imposed a uniform measure of the expected quantitative impact of decisions with regard to project plans and schedules.

6.1 Experience at the Sinmalike Dockyard Corporation.

The applicability of CPM/PERT in Project management has been experimented mainly at the SDC during the period when the corporation has to fulfil a contractual order of twelve 500 - ton oil barges within the time limit of twelve months.

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1. Ernest Dale and L.C. Michelon, Modern Management Methods. (England, W. Foulsham & Co. Ltd, 1966). p.166.
2. R.L. Martino, op.cit., p.2.

By using CPM/PERT, a feasible plan can be formulated to finish the project within the time constraint. It is necessary to construct one oil barge per month on the average, if the contract of the oil barge construction project contract is to be completed within one year. According to the plan formulated by CPM/PERT techniques, it will take even less than one month to construct an oil barge.

As mentioned above, penalty must be paid if the Dockyard cannot handover the oil barges within the contracted period. By implementing the suggested plan successfully, it is certain that the project will be completed in time, and it will save the corporation from paying penalty. Besides, the customer will also be satisfied as their order can be fulfilled according to the contracted time, and more important, they will have confidence in the corporation.

An enterprise that cannot plan systematically will not be able to compete with others. The target date will be unknown, and the customer's confidence cannot be gained. In the past, the corporation had the experience of being unable to supply the orders in time and lost many prospective customers. At that time, it did not matter much, since the corporation was not running on commercial basis.

As the corporation is working on commercial basis at present, it is very important to gain customer's confidence. Only then, the corporation will have enough volume of work so as to increase the probability of obtaining profit. Without a systematic plan, it will not be certain that the project will be completed at the target date and no customer can be expected to have confidence in the ability of the corporation.

By applying the CPM/PERT technique in project management, the Sinmalike Dockyard Corporation and other corporations which are running on commercial basis, (e.g. Construction Corporation) will be able to formulate systematic plans to manage their projects effectively. Therefore CPM/PERT can be an aid to project management of the Dockyard Corporation and other corporations, to run their business successfully on commercial basis, which is the guiding policy of the government.

6.2 Factors to be Considered for the Successful Application of CPM/PERT.

The CPM/PERT is a new and powerful management tool for planning and control of all types of projects. Though the technique has been extensively and successfully applied in industrially developed countries, the experience at the Sinmalike Dockyard Corporation and

Construction Corporation reveals that there may be a number of factors impeding the application of the technique in the Burmese industrial environment. These factors can be stated as follows.

(a) Organizational Arrangement.

The existing organizational arrangement in Burmese industries seem unable to cope wth project monitoring and implementing process through CPM/PERT technique. Experience at the S.D.C. and Construction Corporation indicates that organization for project implementation is far from being able to make effective planning and control. The functions of staff and personnel are not clearly defined and their actual performances are not in accord with what they should be, resulting in improper assignment of duties. What is evident in most cases is, inadequate inspection system, lack of good management discipline, inadequate delegation of responsibility and authority, and inefficient follow-up of work progress.

Planning and controlling projects through the use of CPM/PERT demands proper management discipline, which includes strong management control at planning and controlling phases, smooth coorporstion between executive and technical staff, and efficient management reporting system. Because of the lack of proper management discipline, project failures will often be blamed on the CPM/PERT rather than on the management which has failed to grasp its potentials.

The activity which has the most far reaching effect on the project is the extent, detail and realism of project plans. Unfortunately, there were no specific departments for planning and control of projects in most of the industries in Burma until 1968. Planning is not yet efficient and systematic. Usually, there is not enough time for planning, between, decision and execution. In some cases, frequent changes of decisions make planning impracticable and the work is delayed.

Most often, groups or departments, although on the same project, operate in almost isolation from one another with no coordination between their work. Considerable time elapses from the moment a need for certain action is recognized and the corrective action is taken and carried out.

(b) Assistance of Personnel and Workers.

The task of preparing valid network diagrams, and the logic of the strategy of the project, and obtaining time estimates for activities, require persons who are qualified enough to understand the CPM/PERT technique and who have the experience in scheduling work. At least one member of the planning team should be familiar with the data processing operations and procedures.

It seems that there are only few qualified personnel in Burmese industries, who will be able to execute CPM/PERT application. There is also a general feeling that promotion to better paid jobs is responsible for the increase in satisfaction of the personnel and staff. As the promotion for personnel and staff is usually delayed, qualified staff look for better jobs, resulting in inadequate personnel and staff.

Lack of technically trained workers (ie. skilled workers) may also be a limiting factor in applying CPM/PERT technique, which will cause repetition of work, wasteful delays, and overruns of costs. Because of low income, some look for outside money during their working hours, causing absentees and a decline in their productivity. As the incentive system is not widely introduced yet, in most cases, workers lose interest in work and their idleness formed a bottleneck in carrying out their work continuously. Recruitment and training of personnel and workers seem to be inadequate in most industries. Unless there is a keen assistance of qualified staff and skilled workers, application of CPM/PERT will not be effective.

(c) Procurement System.

One of the fundamentals of CPM/PERT technique is that each activity must be viewed in isolation on the assumption that all necessary resources (labour, materials, and funds) will be available.

Because of the difficulties in procurement system, both foreign and local materials are often of low quality, and inadequate supply cause considerable delays. On the other hand, lack of specific machines, obsolescence of machines, low quality of locally produced tools and equipments cause extra work and wastages.

The ordering of materials and equipments must go through a procedure involving several steps. Since there are no national engineering standards on design and quality control, the process of procuring materials and equipments is complicated and time consuming. In most cases, being a scarce resource, sufficient budget is usually not available and obtaining foreign exchange is prolonged. Thus, the completion of projects within originally planned time and cost targets become increasingly difficult. Difficulties in procurement system may also be deterring factors in CPM/PERT application in Burmese industries.

(d) Attitudes of Top Management and Operating Personnel.

Without the interest and enthusiasm of the organization concerned, the introduction of the CPM/PERT technique as a planning and control tool will not at all be successful.

The attitudes of the people working on the project, determine the success or failure of the introduction of CPM/PERT. Management control and tools are only a framework and a measure for project operations. The real substance of a project is the work performed by the people assigned to it. The enthusiasm that they have for the project may be worth more than PERT.

There is a general feeling that the top management is interested in any kind of improvement in efficiency of the organization, but the operating personnel is ignorant of what the improvements will mean and they have no readiness for new experience. Since there have been lack of duty consciousness, and lack of work discipline due to monetary inflation and improper management of the supervisors,[1] operating personnel might have a sense of acquiring welfare and wage rather than taking pride in achievement and skill through their experience. Thus, it may be difficult to coordinate them to provide

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1. This point is also stated in the "short term and long term economic policy of the Burma Socialist Program Party", 1973, (in Burmese). p.25.

the top management with the information required for detailed planning by CPM/PERT technique.

One obstacle standing in the way of full utilization of CPM/PERT system may be "resistance to change" by the operating personnel. Workers usually resist attempts by management to alter familiar work procedures and to modify existing work regulations.

All people tend to resist changes that they do not understand. The would-be CPM/PERT personnel and workers are individuals with human emotions, hopes and fears. Just because top management holds that the CPM/PERT system will advance the best interest of the enterprise, one cannot assume that this same opinion is shared by the employees. The fears of employees may concern loss of job, reduction of wages, and increase in working hours or intensity of labour.

Any program is likely to fail simply if the need cannot be established prior to the attempted introduction. Since needs are not experienced in the same way by all concerned, no one need-satisfying object will necessarily be acceptable to all.

In many instances, resistance to change may be due to lack of interest, of practical appreciation of the need that might be fulfilled by the application of CPM/PERT.

Thus, unaware of the potentialities of the CPM/PERT technique, and benefit obtained, the operating personnel may not understand the need for accurate and timely action on their part for the application of the technique. Without the eager response of the operating personnel and top management, the implementation of a planning system through CPM/PERT technique will not yield any favourable results.

6.3 Suggested Procedure for CPM/PERT Application.

Project planning and control by CPM/PERT could in due course bring the state enterprises nearer to the goal of fully commercialized organizations. As any practical application of new techniques take time, the objective should be progress, rather than perfection in applying the technique. For this purpose the following factors should be considered.

(a) Before the Application of the CPM/PERT technique, the top management should first be oriented and become acquainted with the technique and its capabilities in saving time, resources and costs. Without the top management's appreciation for the systems and methods used, no worthwhile results can be expected.

(b) Manpower planning should include recruitment, training programs and educational programs, for the long term development of skilled workers and qualkfied personnel. Suitable material incentive systems should be installed widely and effectively so as to increase the productivity and efficiency of the operating personnel.

In any case, a sense of achievement, rather than acquiring welfare should be formed as part of the workers' attitude, so that they can take pride in their work and satisfaction in achievement earned by their day's work. The cooperation of the Peoples' Workers' Council and Lazin Party should be instrumental in promoting the correct attitude and morale of the workers, and coordinating them, as stated in the economic policy of the government.

(c) Organizational arrangement is an important factor in the application of CPM/PERT technique. Without the proper organizational arrangement, the technique cannot yield benefits. Thus, the arrangement should be revised, and required actions should be taken. The responsibilities and duties of the operating personnel should be clearly defined so that their performances may be efficient. If a clear delineation of rights to supervisors could be effectively introduced, as stated in the economic policy of the government, the difficulties and disturbances in the project implementation process will be reduced to the minimu without delay.

Resistance to change that stems from fear of the unknown or from dread of the uncertain can in large measure be minimized by an effective communication system. Lack of reliable information on which to base a decision is one reason why men have at times impeded the introduction of new methods. Once the reasons for the application of new techniques became known, the man involved in the shift will probably begin assessing its impact upon their work and their positions. Therefore, sufficient information concerning not only what is going to happen, but also why it should, ought to be provided when introducing the new technique. It is also necessary to motivate the would be CPM/PERT personnel, so that they may accept and support the change.

A separate planning team should be formed, who will prepare the charts, graphs, abstracts, reports etc. This team should acts as the main general information center and exchange. The members of the team should be knowledgeable in the mechanics of CPM/PERT technique, and they should be familiar with computer operations.

(d) In procuring raw materials, tools and equipments, the local industries which having their own production targets to be met, could not serve adequately as suppliers. Thus, the cooperation with the allied corporations and proper contracts should be made in procuring local raw materials and equipments, so that the required quality, and quantity could be obtained whenever necessary. However, large cost items like machinery must still be relied on foreign suppliers. It is hoped that, in the near future, the National Engineering standards will be developed for use in industry. Only then, work simplification and evaluation could be carried out effectively, so that follow--up of work progress will be systematic. Furthermore, it will be more convenient for the corporations in ordering the foreign materials according to the national standards.

If the state enterprises can only operate effectively as stated in the short term and long term economic policy of the Burma Socialist Program Party, especially such factors as, running the state enterprises on commercial basis, introducing material incentive system or reward and punishment system, delegating the rights and responsibilities to supervisors, relying on the local made materials and equipments, organizing the workers with the help of Peoples' Workers' Council, the application of CPM/PERT in project management is likely to benefit in such an environment.

If the state enterprises are to operate effectively according to the policy guide lines of the government, they should introduce CPM/PERT for systematic project planning and control so that their objectives will be fulfilled.

6.4 Minimum Conditions for the Application of CPM PERT.

In applying CPM/PERT technique, the existing environmental factors of the Burmese industries must be taken as constants. Factors such as inefficiency of the organization, difficulties in the procurement system, lack of qualified personnel and skilled workers, lack of tools and equipments, have been the major characteristics.

There have been no specific departments for planning and control of projects in the Sinmalike Dockyard Corporation. What is evident in S.D.C. as in most of the cases is lack of good management discipline, and inadequate delegation of responsibility.

The recruitment and training pattern of the S.D.C. still has to be coincided with the need of the organization. For example, the personnel who are interested in shipbuilding should be recruited rather than the persons who joined the S.D.C. as a stepping stone, to get the jobs of ocean going seamen or technicians.

There have been difficulties also in the procurement system. Since the prices are not stable, the exact inflation rate is not available and it is difficult to estimate the required budget. Being a scarce resource the amount of the alloted budget is inadequate in most cases, and it causes delays in project implementation.

As the process of procuring raw materials and machines is complicated and time consuming, there have been lack of machines and equipments, and the required quantity and quality of raw materials are not available in time. Thus the amount of uncertainties is increased and there have been repetition of work and wasteful delays during the project implementation. In spite of these unfavourable conditions and uncertainties of the industrial environment, experimental application of CPM/PERT at the S.D.C. could be reckoned as successful.

Thus, there are some conditions for the successful application of CPM/PERT if the above mentioned factors are treated as constants, since they have been always dominating the Burmese industrial environment.

Attitudes of the top management is important before the application of CPM/PERT. Top management must be well acquainted with CPM/PERT technique and its capabilities in saving time, resources and costs. Top Management must also have a sense of systematic scheduling and must be interested in the efficiency of the organization. Without the eager response and appreciation of the top management, the implementation of a planning system through CPM/PERT could never be successful.

The projects which are to be controlled and monitored by CPM/PERT technique must be a one-time effort, and where more uncertainties are encountered.

In applying CPM/PERT the detailed information about the project must also be made available. Historical information should also be gathered and documented. Information regarding preparation and planning of the project are, specification of machinery and equipment, raw materials preparation of tenders, project activities according to selected levels of detail, activity sequential relationships, methods of performing the project, durations, time schedules and the like.

By using these information, the logic of strategy already adopted can be reviewed and adjusted, and project implementation network can be updated for further use as a control tool.

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